Lake Tahoe Region

Aquatic Invasive Species Management Plan

CALIFORNIA - NEVADA

November 2009

This Aquatic Invasive Species Management Plan is part of a multi-stakeholder collaborative effort to minimize the deleterious effects of nuisance and invasive aquatic species in the Lake Tahoe Region. This specific product is authorized pursuant to Section 108 of Division C of the Consolidated Appropriations Act of 2005, Public Law 108-447 and an interagency agreement between the U.S. Army Corps of Engineers and the California Tahoe Conservancy.

US Army Corps of Engineers ® Sacramento District

CALIFORNIA TAHOE CONSERVANCY

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Acronyms

AIS	Aquatic Invasive Species
ANS	Aquatic Nuisance Species
ANSTF	Aquatic Nuisance Species Task Force
BLM	Bureau of Land Management
CADPR	California Department of Parks and Recreation
CAISMP	California Aquatic Invasive Species Management Plan
CDFA	California Department of Food and Agriculture
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CDPR	California Department of Pesticide Regulation
CRWQCB	California Regional Water Quality Control Board
CSLC	California State Lands Commission
CTC	California Tahoe Conservancy
EDRR	Early detection and rapid response
EIP	Environmental Improvement Program
EMAP	Environmental Monitoring and Assessment Program
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
IDA	Idaho Department of Agriculture
IPM	Integrated Pest Management
ISAC	Invasive Species Advisory Committee
LRWQCB	Lahontan Regional Water Quality Control Board
LTAISCC	Lake Tahoe Aquatic Invasive Species Coordination Committee
LTAISWG	Lake Tahoe Aquatic Invasive Species Working Group
LTFAC	Lake Tahoe Federal Advisory Committee
LTSLT	League to Save Lake Tahoe
NAC	Nevada Administrative Code
NANPCA	Nonindigenous Aquatic Nuisance Prevention and Control Act
NDA	Nevada Department of Agriculture
NDEP	Nevada Department of Environmental Protection
NDOW	Nevada Department of Wildlife
NDSL	Nevada Division of State Lands
NDSP	Nevada Division of State Parks
NEPA	National Environmental Policy Act

Acronyms cont.

NFMA	National Forest Land Management Act
NISA	National Invasive Species Act
NISC	National Invasive Species Council
NLTLPF	Nevada Lake Tahoe License Plate Fund
NRS	Nevada Revised Statutes
ONRW	Outstanding National Resource Water
OSU	Oregon State University
PSU	Portland State University
SNPLMA	Southern Nevada Public Land Management Act
TDC	Tahoe Divers Conservancy
TERC	Tahoe Environmental Research Center
TIE	Tahoe Interagency Executive
TKPOA	Tahoe Keys Property Owners Association
TMWQ	Truckee Meadow Water Authority
TRCD	Tahoe Resource Conservation District
TRPA	Tahoe Regional Planning Agency
TSC	Tahoe Science Consortium
TWSA	Tahoe Water Suppliers Association
UCCE	University of California Cooperative Extension
UCD	University of California, Davis
UNR	University of Nevada, Reno
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
- APHIS	Animal and Plant Health Inspection Service
- APHIS - PPQ	Animal & Plant Health Inspection Service – Plant Protection & Quarantine
- ARS	Agricultural Research Service
- NAL	National Agricultural Library
- NRCS	Natural Resource Conservation Service
- USFS - LTBMU	United States Forest Service – Lake Tahoe Basin Management Unit
USDOI	United States Department of Interior
- BLM	Bureau of Land Management
- USBOR	United States Bureau of Reclamation
- USFWS	United States Fish and Wildlife Service
- USGS	United States Geological Survey
VIP	Vessel Inspection Plan
WRP	Western Regional Panel

Glossary

Abscission point: The area of a plant where physiological changes allow for natural separation between adjacent areas of vegetation.

Accidental introduction: An introduction of nonindigenous species that occurs as the result of activities other than the purposeful or intentional introduction of the species involved, such as the transport of nonindigenous species in ballast water or in water used to transport fish, mollusks or crustaceans for aquaculture or other purposes.

Adaptive Management: Refinement of an approach (and sometimes objectives) to an environmental implementation plan that is modified based on outcome of initial results. The plan may continually be refined so that positive environmental results are achieved.

Algae bloom: A rapid increase in a population of algae in an aquatic system; usually occurs resulting from a nutrification event.

Allofragments: Fragments of vegetation produced by mechanical means such as boat propellers or mechanical harvesting.

Anoxic environment: An environment with exceedingly low levels of oxygen.

Aquaculture: The farming of freshwater or saltwater organisms including mollusks, crustaceans, and aquatic plants.

Aquascape: Aesthetic gardening in an aquatic area with aquatic species.

Aquatic species: All animals and plants as well as pathogens or parasites of aquatic animals and plants totally dependent on aquatic ecosystems for at least a portion of their life cycle (ANSTF 1994).

Aquatic invasive species (AIS): A nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters (NANPCA 1990).

Autofragments: Self-formed fragments of vegetation produced through the development of an abscission point.

Ballast: An often water-filled device used on ships and submersibles to control buoyancy and stability.

Ballast water: Any water and associated sediments used onboard a ship to increase the draft, change the trim, regulate the stability or maintain the stress loads of the vessel.

Bathymetric: Of or relating to measurements of the depths of oceans or lakes.

Benthic (benthos): The ecological region located at the deepest level of a body of water; this includes the area around the interface between the sediment surface and water column.

Bilge: The lowest compartment on a ship or boat where water that is taken-on while floating on a water body collects and pools.

Biocontrol: The use of living organisms, such as predators, parasites and pathogens, to control pest animals (e.g., insects), weeds or diseases.

Bio-fouling: The undesirable accumulation of living or dead organisms on submersed structures (pipes, boat hulls, piers, anchors, rocks, et cetera) or other organisms.

Bivalve: Mollusks belonging to the class Bivalvia that are characterized by having a shell composed of two parts or valves.

Byssal threads: Fibers produced by bivalves that function to anchor individuals to their substrate.

Chironomid: Minute, long-legged, non-biting, two-winged flies with piercing mouthparts.

Glossary cont.

Cladocerans: Small crustaceans, commonly called water fleas, found in most freshwater habitats, including lakes, ponds, streams and rivers.

Coldwater fish: Fish species that prefer and inhabit colder waters; examples are salmonid species such as trout and salmon.

Concentration (chemistry): The density of an environmental component in a defined area.

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

Crustacean: A large group of mostly aquatic arthropods that includes various species such as crab, lobster, crayfish, shrimp, krill, and barnacle.

Cryptogenic species: An organism of unknown origin; may be introduced or native.

Detritus: Non-living particulate organic material derived from living organisms.

Dispersed recreation: Passive forest outdoor recreation that occurs outside of developed sites with modern facilities and where concentration use occurs.

Dreissenid: A family of small, often invasive, freshwater mussels in the phylum Molllusca.

Ecological integrity: The extent to which an ecosystem has been altered by human behavior; an ecosystem with minimal impact from human activity has a high level of integrity; an ecosystem that has been substantially altered by human activity has a low level of integrity.

Eradicate: For the purpose of this Plan, eradication is the complete elimination of an invasive species from a specific part of the Lake Tahoe Region or the entire Region.

Established: An introduced organism with a permanent population(s), i.e., one that has the ability to reproduce and is not likely to be eliminated by humans or natural causes.

Eutrophic: A lake condition of high production associated with high phosphorus and nitrogen.

Excurrent siphon: An organ of a mollusk from which water and waste are expelled.

Exoskeleton: An external skeleton that supports and protects the body of an arthropod (invertebrate).

Exotic: Any species or other variable biological material that enters an ecosystem beyond its historic range, including such organisms transferred from one country to another. Also known as nonindigenous or non-native.

Filter feeder: An aquatic animal, such as a mussel or clam that feeds by filtering particulate organic material from water.

Fouling: An accumulation of organisms that attaches to naturally occurring and manmade submerged hard surfaces such as rocks, shells, ships, intake pipes, and other submerged equipment or machinery. Mobile organisms that may be tucked in nooks created by the larger animals are also considered part of the "fouling community".

Genetic dilution: Genetic dilution occurs when introduced organisms add their genetic material to native populations through hybridization. This can result in populations that are less well adapted to their environment, potentially leading to the decline of those populations.

Hermaphroditic: An organism having both male and female reproductive organs; allowing the potential for self-fertilization.

Herpetofauna: A guild of vertebrates that includes amphibians and reptiles.

Glossary cont.

Host: A living animal or plant that supports parasitic animals, plants or microbes, internally or on its surface.

Incipient infestation: A small colony of an invasive species that has spread to a new area.

Indigenous: An organism that is native or naturally evolved to a specific region in which it naturally occurs.

Integrated Pest Management (IPM): A decision-based process involving coordinated use of multiple tactics for optimizing the control of all classes of pests (insects, pathogens, weeds, vertebrates) in an ecologically and economically sound manner.

Intentional introduction: All or part of the process by which a nonindigenous species is purposefully introduced into a new area.

Introduction: The intentional or unintentional escape, release, dissemination or placement of a species into a California ecosystem as a result of human activity.

Invasive species: An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112 [Federal Register: Feb 8, 1999, Vol. 64, No. 25]). Species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy (CDFG 2008).

Keystone species: A species whose loss would have a disproportionately large effect on its ecosystem relative to its abundance.

Limnetic zone: The area of a lake that is characterized by open surface waters away from the shore and high light penetration for primary producers.

Littoral zone: The area in an aquatic environment found between the high-water mark and the permanently submerged nearshore area.

Macroinvertebrate: An invertebrate large enough to be visible to the naked eye.

Macrophyte: An emergent, submerged or floating aquatic plant large enough to be visible to the naked eye that provides cover, substrate, and oxygen for aquatic animals.

Meso-eutrophic: A lake condition of moderately high production associated with moderately high phosphorus and nitrogen.

Metamorphs: A change in the form and often habits of an animal during normal development after the embryonic stage; also refers to the individual who is undergoing the change.

Microzooplankton: A community of zooplankton composed of animals to small to be seen with the naked eye.

Mollusks: Invertebrates belonging to the phylum Mollusca that live in diverse habitats in marine, freshwater, and terrestrial biotopes; includes gastropods (snails), clams, and mussels.

Native species: A species within its natural range or natural zone of dispersal, i.e., within the range it would or could occupy without direct or indirect introduction and/or care by humans.

Glossary cont.

Non-native or Nonindigenous species: A species that enters an ecosystem beyond its historic geographic range. Also known as exotic or alien species. Other taxa can be considered non-native or nonindigenous, such as families, genera, subspecies or varieties.

Non-point source pollution: Pollution that comes from a general, non-specific area.

Nuisance species: For the purpose of this plan, the term is synonymous with invasive species.

Oligotrophic: A lake condition of low production associated with low phosphorus and nitrogen.

Operculum (invertebrate): A hard covering used by gastropods (snails) to close the opening to their shell.

Organic (ecological): Matter that has come from a once-living organism; is capable of decay, or the product of decay; or is composed of organic compounds.

Parthenogenic: A form of reproduction in which an unfertilized egg develops into a new individual (i.e. fertilization is not required for egg development), resulting in an all female clonal population; occurs commonly among insects and some other arthropods.

Pathogen: A microbe or other organism that causes disease.

Pathway: Mode by which a species establishes and continues to exist in a new environment (Heutte and Bella 2003); often synonymous with vector, dispersal mechanism, and mode. Natural and human connections that allow movement of species or their reproductive propagules from place to place (CDFG 2008).

Pelagic zone: The zone of a water body with only water being present as the media or in space; open water.

Perennial: A plant that lives for multiple years.

Photic zone: The food-rich area of open water in a lake or ocean that is exposed to sunlight sufficient for photosynthesis to occur.

Phytoplankton: Free-floating microscopic plants (primary producers) that compose the autotrophic component of the plankton community.

Pioneer infestation: See incipient infestation.

Polytrophic: Subsisting on various types of organic material.

Propagule: Any plant material used for the purpose of plant asexual propagation.

Refugia: An area of refuge or protection from potentially change-inducing external forces.

Re-suspension: Suspending of settled sediments that have been suspended in the past.

Rhizome: A specialized plant stem that often sends out roots and shoots from its nodes for asexual reproduction.

Senesce (plant): A natural response in plants where single plant organs (e.g., leaves) or entire plants are lost as metabolically expensive nutrients are moved to surviving plant organs.

Seston: Particulate matter such as plankton, organic detritus, or inorganic particles such as silt that are suspended in water.

Spatial partitioning: A physical redistribution of competitive organisms in space.

Stakeholder: Relevant representatives from regional, state, or federal agencies, non-governmental organizations, or property owners.

Glossary cont.

Stolon: A specialized colonizing plant organ that is often a horizontal above-ground shoot that arises from an axillary bud near the base of the plant.

Substrate: The base on which an organism lives and grows.

Taxa: Groups used to classify organisms (e.g., kingdom, phylum, class, order, family, genus and species). Taxa is the plural form of taxon.

Tuber: A specialized modified plant structure that is enlarged to store nutrients.

Turion: A wintering bud of water plant that breaks off and lies submerged and dormant until the following spring, when it produces a new plantlet that floats to the surface.

Ultra-oligotrophic: A lake condition of extreme low production commonly associated with very low phosphorus and nitrogen.

Vector: The physical means or agent by which a species is transported (e.g., boat hulls, live wells, fishing gear); often synonymous with pathway, dispersal mechanism, and mode (Carlton 2001).

Veligers: Free-swimming larvae of mollusks such as clams and mussels.

Viviparous: A reproductive strategy where young are born live and free from incubation structures (i.e., live-bearing).

Watershed: The geographic area that drains to a single water body or hydrographic unit such as a lake, stream reach or estuary.

LAKE TAHOE REGION
AQUATIC INVASIVE SPECIES MANAGEMENT PLAN
CALIFORNIA AND NEVADA

Executive Summary

Lake Tahoe is designated an Outstanding National Resource Water (ONRW) under the Clean Water Act (CWA Section 106) due to its extraordinary clarity. Substantial changes to the Lake Tahoe Region's economy, pristine water quality, aesthetic value, and recreational pursuits are occurring, partly due to the harmful impacts of non-native aquatic plants, fish, invertebrates, and other invaders. These non-native aquatic organisms are considered 'invasive' (or *aquatic invasive species* [AIS] in water) when they threaten the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependant upon such waters (NANPCA 1990). AIS are commonly spread by activities such as boating, fishing, hatchery releases, and aquarium dumping. The Lake Tahoe Region is not only threatened by new introductions of AIS to Lake Tahoe from other waterbodies, but also the expansion of existing populations within the lake and even as a source of AIS to nearby waterbodies.

At least 20 non-native species are established in the Lake Tahoe Region, including aquatic plants, fishes, invertebrates, and an amphibian. As examples, Eurasian watermilfoil (*Myriophyllum spicatum*; an aquatic plant) has been spreading around Lake Tahoe over the last 15-20 years, and curlyleaf pondweed (*Potamogeton crispus*; another aquatic plant) has begun to expand dramatically over the last three years. Beds of Asian clams (*Corbicula fluminea*) are larger and more common than previously known, and populations of warm water fishes such as largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus)* are expanding. Moreover, global climate change has resulted in warmer water temperatures, likely facilitating the establishment of non-native plants in the nearshore environment and providing increased spawning areas for warm water fishes that compete with desirable species.

The potential economic impact to the Lake Tahoe Region caused by new AIS introductions such as quagga or zebra mussels (*Dreissena bugensis* and *D. polymorpha*, respectively) or expanding invasive aquatic plant populations would be substantial. The combined economic impacts to recreation value, tourism spending, property values, and increased boat/pier maintenance, when evaluated over a 50 year period, is estimated at $417.5 million (present value), with an average annual equivalent value of $22.4 million per year. The largest estimated impacts would be to property values and lost tourism spending, each accounting for 38% of the total estimated AIS damages. Spending on prevention and early eradication produces a higher benefit to cost ratio

than post-infestation control programs such that maximum benefits are realized through early and preemptive action.

The 2007 discovery of quagga mussels in Lake Havasu, Lake Mead, and the Colorado River Basin have prompted rapid cooperation and action by regional, bi-state, and federal agencies and non-governmental organizations in the Lake Tahoe Region. These new threats, coupled with recent studies showing high incidence of boat traffic to Lake Tahoe from these areas, have prompted a tremendous ramping up of education and outreach campaigns, new regulations to prevent accidental introduction, and increased control efforts and research on the biology and distribution of existing AIS populations. Examples of these activities include (LTAISWG 2007):

- Formation of the Lake Tahoe AIS Working Group (LTAISWG)
- Formation of the Lake Tahoe AIS Coordination Committee (LTAISCC)
- Yearly workshops organized by the LTAISWG to prioritize AIS prevention, monitoring, control, education, and research efforts
- Development and implementation of a Vessel Inspection Program at Lake Tahoe
- Deployment of portable boat washing stations
- Full-time AIS Coordinator hired by U.S. Fish and Wildlife Service (USFWS)
- Increased monitoring for invasive aquatic plants, invertebrates, and warm water fishes
- Use of diver-operated suction and benthic barriers to control invasive aquatic plants
- Evaluation of diver-operated suction and bottom barriers to control Asian clams
- Measurement of warm water fish behavior and diets in and around the Tahoe Keys
- Increased education and outreach activities
- Quagga mussel survivability studies

Despite these efforts, the Lake Tahoe Region lacks a cohesive guiding document that prioritizes objectives and identifies lead organizations, specific actions for each organization, and funding sources to combat existing and potential AIS. Also needed is further guidance that delineates appropriate, science-based regulation and monitoring that expressly deals with prevention and management of AIS. The purpose of the *Lake Tahoe Region AIS Management Plan* (the Plan) is to facilitate coordination of regional, bi-state, state, and federal programs and to guide implementation of AIS prevention, monitoring, control, education, and research in the Lake Tahoe Region.

The goals of the Plan are to:

- Prevent new introductions of AIS to the Lake Tahoe Region
- Limit the spread of existing AIS populations in the Lake Tahoe Region, by employing strategies that minimize threats to native species, and extirpate existing AIS populations when possible

- Abate harmful ecological, economic, social and public health impacts resulting from AIS

The implementation of the Plan is structured around seven objectives associated with:

A. Management plan implementation and updates

B. Coordination and collaboration

C. Prevention

D. Early detection, rapid response and monitoring

E. Long-term control and management

F. Research and information transfer

G. Laws and regulations

To meet these objectives, 23 strategies are identified with respective action items detailing how that objective will be met. The priority of each of the 95 actions included are ranked as low, medium, or high and the lead and cooperating entities are identified. Where applicable, short-term (present through 2010) priorities for action and funding sources are indicated as are the long-term actions over the five-year period from 2010 to 2015. In many cases, the LTAISWG or LTAISCC are named as the lead or cooperating entities. Currently, the two committees share a common chair.

The intent of the Plan is to provide more localized guidance for preventing and managing AIS in the Lake Tahoe Region and will not be in conflict with the California AIS Management Plan (CAISMP), administered by the California Department and Fish and Game (CDFG) or the anticipated plan from the state of Nevada.

At a minimum, the Plan will be reviewed once a year and revised every five years by a LTAISCC sub-committee to ensure Plan objectives, strategies and actions continue to identify and address relevant AIS issues in a timely manner. Individual components of the Plan (e.g., rapid response plans, monitoring plans, vessel inspection protocols) may be updated more frequently to fully address changing needs in the Lake Tahoe Region.

Summarized in the Plan is the background of non-native species introductions to the Lake Tahoe Region, the pathways for existing and potential AIS introductions, the types of existing and potential AIS in the Lake Tahoe Region, and short- and long-term priorities for action. Also included (as appendices) is an overview of regulations and programs, the Vessel Inspection Plan, the Small Watercraft Screening Process, an estimate of potential economic impacts from a mussel infestation at Lake Tahoe, and an overview of existing and potential AIS life histories, environmental requirements, distributions, and control methods.

1 Introduction

Numerous non-native species have been introduced worldwide intentionally (e.g., cultivars, pet trade, recreation, resource management) and accidentally (e.g., ballast water releases, hitchhikers, recreational pursuits). The nature of the relationship between non-native species and the local landscape is largely based on potential harmful impacts versus societal benefits (ISAC 2006). That is, society may deem the benefits of *purposeful* introductions of non-native species outweigh potential or realized harmful impacts. Conversely, *accidental* introductions, or especially unauthorized intentional introductions, are generally viewed as undesirable and detrimental to the local landscape.

An *invasive* species is one "that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health" (NISC 2008). By extension, an *aquatic* invasive species (AIS) is a "nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters" (NANPCA 1990).

The purpose of the *Lake Tahoe Region AIS Management Plan* (the Plan) is to facilitate coordination of regional, state, and federal programs and to prioritize and guide implementation of AIS prevention, monitoring, control, education, and research actions in the Lake Tahoe Region. Through region-wide stakeholder acceptance, the Plan is an attempt to coordinate and to set timelines for these actions to preserve and protect the environmental, economic and human health in the Lake Tahoe Region.

1.1 Geographic Scope: Lake Tahoe Region

The geographic scope of the Plan is the Lake Tahoe Region (the Region) (Figure 1). As defined by the Tahoe Regional Planning Agency (TRPA) Compact, the Region is located on the California-Nevada border and includes Lake Tahoe (and approximately 6 km of the Lower Truckee River below the lake), the adjacent parts of Douglas and Washoe Counties and Carson City in Nevada and the adjacent parts of Placer and El Dorado Counties in California (TRPA Compact P.L 96-551). The Region drains 63 streams to Lake Tahoe with the Upper Truckee River being the largest. The lake's only outflow, after passing the Lake Tahoe Dam, is the Lower Truckee River at Tahoe City. Beyond the Region boundaries, the Truckee River continues to flow approximately 140 miles to its terminus at Pyramid Lake (Murphy et al. 2000; USBOR 2008). In addition to Lake Tahoe, many smaller lakes and six larger recreation lakes (Fallen Leaf, Echo, and Cascade Lakes in California; Marlette, Spooner, and Incline Lakes in Nevada) are located in the Region.

The majority of the land in the Region is owned and managed by public agencies. Approximately 80% of the public lands are managed by the U.S. Department of Agriculture -

U.S. Forest Service – Lake Tahoe Basin Management Unit (USDA-USFS-LTBMU). There are nine state parks on the California side managed by California Department of Parks and Recreation (CADPR) and the Lake Tahoe Nevada State Park managed by Nevada Division of State Parks (NDSP) on the Nevada side. Also in the Region, the California Tahoe Conservancy (CTC) owns large and small land parcels and the Nevada Division of State Lands (NDSL) owns and manages approximately 500 urban parcels. Most of the private lands are commercially held with most development is in the low lying areas near the lake.The TRPA directs land use and development issues in the Region (see Appendix A for further information on agency jurisdiction).

South Lake Tahoe, the only incorporated city in the Tahoe Basin, occupies the south shore of the lake. With respect to AIS, of note is the Tahoe Keys, also on the south shore. The Keys, as it is commonly referred to, is a residential development that includes two marinas. The residential marina is in a western channel and the commercial marina is in an eastern channel, referred to as Tahoe Keys West and Tahoe Keys East, respectively. The Tahoe Keys were constructed within the Upper Truckee Marsh in the mid-1960s when water from the Upper Truckee River was channelized and diverted to prevent flooding. The result is that surface water exchange between the Tahoe Keys and the main body of Lake Tahoe is now limited to the two channels. Water in the Keys is shallower, turbid and warmer, providing habitat for numerous AIS.

Lake Tahoe's water clarity (the depth of light penetration) is one of its most striking features. Lake Tahoe is designated an Outstanding National Resource Water (ONRW) under the federal Clean Water Act (CWA) (1972) as nominated by the California Regional Water Quality Control Board (CRWQCB). Likewise, Lake Tahoe is designated a "water of extraordinary ecological or aesthetic value" by the Nevada Division of Environmental Protection (NDEP). Lake Tahoe has a mean depth of 305 m (maximum 501 m), second only in the U.S. to the depth of Crater Lake (also designated an ONRW) in Oregon.

Regularly recorded Secchi depths (a measurement of water clarity) have occurred in Lake Tahoe since the late 1960s. Since that time, transparency of up to 41 m has been recorded; however, it has declined up to 0.27 m $year^{-1}$ (Jassby et al. 2003) with recent measurements of 21.4 m (TERC 2008), suggesting a shift in the lake's oligotrophic status (Goldman 1974, Goldman 1988). The ongoing decline in Lake Tahoe's water clarity is a result of light scatter from fine sediment particles (primarily particles less than 16 micrometers in diameter) and light absorption by phytoplankton, resulting in an increased shift in the lake's depth of maximum chlorophyll (LRWQCB and NDEP 2007). The addition of nitrogen and phosphorus to Lake Tahoe contributes to phytoplankton growth. Fine sediment particles are the most dominant pollutant contributing to the impairment of lake waters, accounting for an estimated two thirds of the lake's impairment. The decline of Lake Tahoe's clarity resulted in the listing of Lake Tahoe as impaired for the transparency standard under Section 303(d) of the Clean Water Act. Lake Tahoe's 303(d) listing compelled California and Nevada to develop a Total Maximum Daily Load (TMDL) (under peer review).

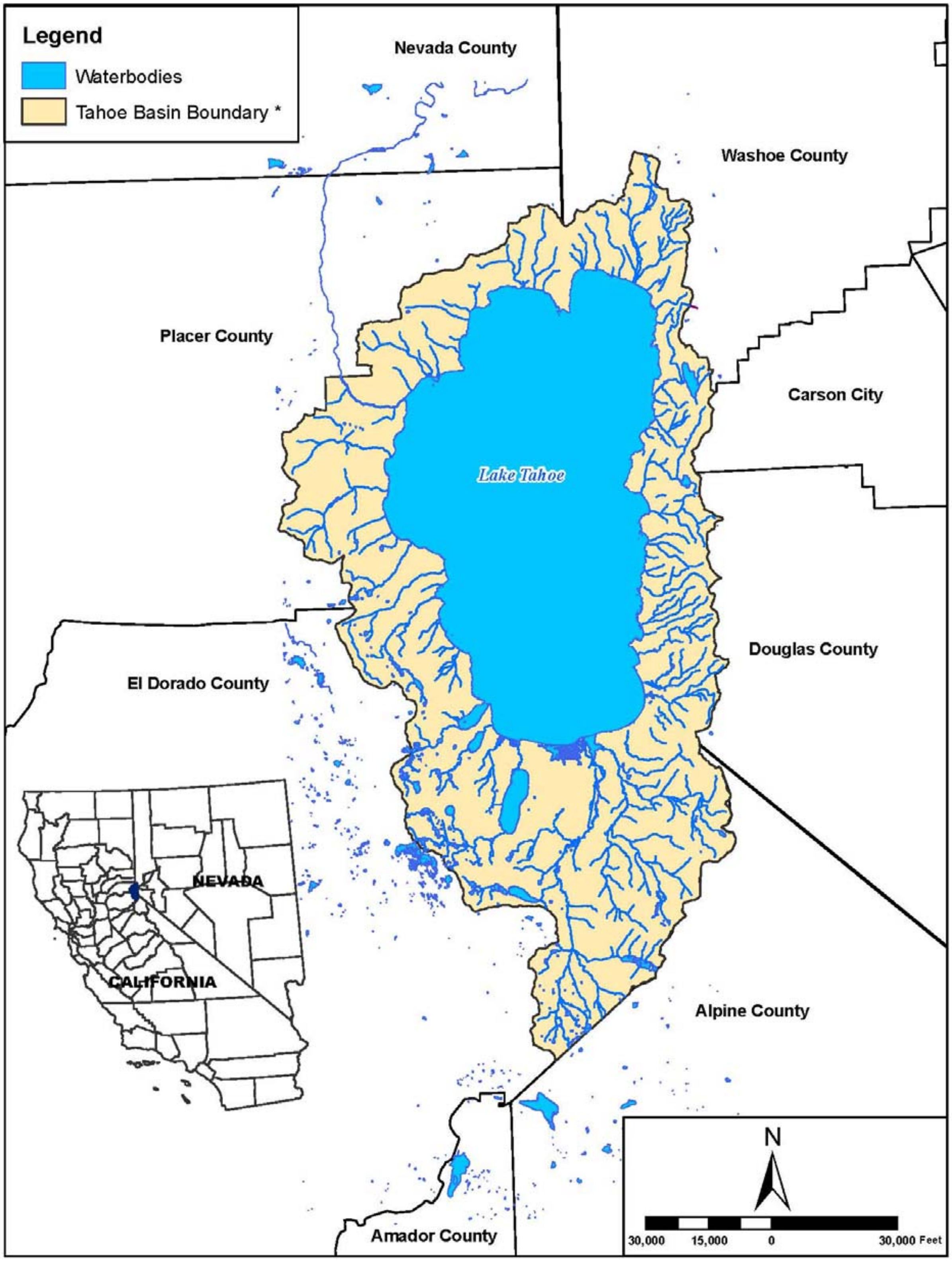

Figure 1. Lake Tahoe Region (Source: TRPA)

Despite its relatively small watershed (812 km^2), Lake Tahoe has a surface area of approximately 500 km^2. This low watershed-to-lake ratio (1.6:1) results in a substantial amount of precipitation falling directly on Lake Tahoe, contributing to its oligotrophic status. It is a subalpine lake (elevation 1,897 m) surrounded by mountains over 1,200 m above lake level (LRWQCB and NDEP 2007). Typical surface water temperatures range from 18 to 21°C during late summer and between 4.5 to 10°C during the winter. Evidence by Coats et al. (2006); however, strongly suggest increases in the thermal structure of Lake Tahoe, possibly facilitating further colonization and expansion of AIS (UCD 2008).

1.2 Existing Authorities and Programs

Numerous federal, state, and regional regulations and programs are in place in the Region, to limit the introduction and spread of AIS with no single agency or group responsible for all AIS issues. Table 1 lists the various agencies, regulations and programs associated with AIS in the Region. As an interstate AIS management plan, management actions presented in this Plan consider the overlapping jurisdictions of the States of California and Nevada as well as the areawide role of the TRPA. A comprehensive summary of regulations and programs currently in place may be found in Appendix A.

Federal authority to limit the interstate transport and importation to the U.S. of prohibited plant species is provided by the USDA-Animal and Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) (Plant Protection Act of 2000) and prohibited wildlife species authority is provided by the U.S. Fish and Wildlife Service (USFWS) (Lacey Act) (Appendix A).

In California, the California Department of Fish and Game (CDFG) is responsible for prohibited fish and wildlife resources (CCR, Title 14) and is the lead agency for the California AIS Management Plan (CAISMP). The CAISMP defines invasive species as those

> …that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy.

The purpose of the CAISMP is "to coordinate state programs, create a statewide decision-making structure and provide a shared baseline of data and agreed-upon actions so that state agencies may work together more efficiently". The CAISMP addresses numerous AIS presently established in or threatening introduction to aquatic ecosystems throughout the state. Waterbody types addressed include creeks, wetlands, rivers, bays, and coastal water habitats (CDFG 2008).

The CAISMP describes vectors of concern on a statewide-scale including: commercial shipping and fishing, recreational equipment and activities, trade in live organisms (e.g., aquarium trade), construction in aquatic environments, and water delivery and diversion systems (CDFG 2008).

California Department of Fish and Game (DFG) Code §2301 allows CDFG designated staff (and other authorized state authorities, i.e., CADPR peace officers and California Department of Food and Agriculture [CDFA]) to inspect, impound or quarantine any conveyance (e.g., watercraft) that may carry dreissenid mussels (i.e., quagga and zebra mussels). CDFA is the lead agency for regulatory activities associated with noxious weeds (CAC Title 3, Sec. 3400). Also in California, the Lahontan Region Water Quality Control Board (LRWQCB) is responsible for regionwide water quality objectives as outlined in the *Water Quality Control Plan for the Lahontan Region North and South Basins* (commonly referred to as the Basin Plan; CRWQCB 2005). With respect to managing AIS, the Basin Plan states that regionwide water quality objectives for pesticides, and related objectives for nondegradation and toxicity, essentially preclude direct discharges of pesticides such as aquatic herbicides (see Appendix A).

In Nevada, the Nevada Department of Agriculture (NDA) is the lead agency for regulatory activities associated with noxious weeds and the Nevada Department of Wildlife (NDOW) is the lead agency for regulatory activities associated with prohibited wildlife. Under NRS Title 14 Chapter 171.123, any peace officer (e.g., NDOW Game Warden, county sheriff deputy, city police agencies) may detain a person that has committed, is committing or is about to commit a crime (e.g., possession of state listed prohibited wildlife [NAC 503.110] or plant [NAC 555.010] species). Additionally, NDOW Game Wardens (or other Nevada peace officers), as deputies of the USFWS have the authority to uphold provisions of the Lacey Act (Appendix A). Nevada is currently without a comprehensive AIS management plan and instead must rely on the disparate efforts of regional, state, and federal agencies. The state has, however, has completed draft guidance to prevent and monitor for AIS, particularly quagga mussel. Once a key staff position is filled with NDOW, completing and implementing the “Prevention and Disinfection Guidelines” and the “Quagga Mussel Monitoring Program” will be top priorities.

The Nevada Board of Wildlife Commissioners has set policy that clearly supports programs that would limit the introduction and impacts of undesirable aquatic species (P-33 Fisheries Management Program). The U.S. Department of Interior – Bureau of Land Management (USDOI-BLM) Nevada State Office maintains a website for their Invasive Species Initiative for reporting invasive species, but it is not specific to aquatic organisms. Likewise, efforts of the Nevada Invasive Species Council are not focused on *aquatic* invasive species. Quagga mussels have been found in Nevada lakes (e.g., Lake Mead) that are also popular destinations for Lake Tahoe visitors (Wittmann 2008). Presently there is limited mandatory boat inspection or washing for boats leaving infested waterbodies in Nevada; however, boat inspection procedures are evolving.

Region-wide efforts include the designation of TRPA as an area wide planning agency under Section 208 of the federal CWA to maintain water quality measures specified in the *Water Quality Management Plan for the Lake Tahoe Basin* (208 Plan) by limiting the impacts of tourism, ranching, logging, and development on the Lake Tahoe environment and enforcing environmental thresholds. TRPA and its Governing Board has taken an aggressive and proactive role in preventing the introduction of new AIS to Lake Tahoe. The TRPA has the authority to inspect all boats entering Lake Tahoe for AIS or issue penalties starting at $5,000 (TRPA Code of Ordinances Chapter 79.3. B). CADPR peace officers (or other state agencies with CDFG Director approval) have the authority to enforce California DFG Code §2301 (related to dreissenid mussel inspections). As of November 1, 2008, all boat launches (public and private) without a trained inspector are closed (TRPA Code of Ordinances, Chapter 79.3.B (1) and (2)).

TRPA defines an invasive species as:

> "…both aquatic and terrestrial, that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy (TRPA Code of Ordinances, Chapter 79.3)."

Table 1. Federal, State, and Regional Agencies, Regulations and Programs in the Lake Tahoe Region and Associated AIS Activities

	Control	Coordination	Documentation	Education/ outreach	Eradication	Exportation	Financial Assistance	Importation	Possession	Prevention	Quarantine	Research	Technical Assistance
Federal*													
Endangered Species Act of 1973	x				x								
Executive Order 13057		x											
Executive Order 13112		x		x			x			x			x
Lacey Act of 1990 (amended 1998)								x	x				
NANPCA (1990) and NISA (1996)	x	x		x			x			x		x	x
NEPA of 1970			x										
USACE		x					x					x	x
USDA	x	x		x	x		x			x		x	x
USDOI	x	x		x	x		x			x		x	x
State and Regional*													
CADPR	x	x		x	x					x	x	x	x
CDFA	x	x	x	x	x	x		x	x	x			x
CDFG	x	x		x	x	x		x	x	x	x	x	x
CEQA	x		x		x					x			
CSLC	x	x					x						
CTC				x			x			x			
EIP		x					x					x	
LRWCQB (CRWQCB 2005)	x	x		x			x			x			

Table 1. cont.

	Control	Coordination	Documentation	Education/ outreach	Eradication	Exportation	Financial Assistance	Importation	Possession	Prevention	Quarantine	Research	Technical Assistance
State and Regional cont.													
LTAISCC	x	x	x	x	x					x		x	x
LTAISWG	x	x		x	x					x		x	x
LTSLT				x			x			x			
NDOW	x			x	x	x		x	x	x	x		x
NDSL		x					x						
NDSP		x		x						x			
Tahoe Area Sierra Club Group				x						x			
Tahoe Science Advisory Group		x											
TKPOA	x												
TRCD	x	x		x	x		x			x			x
TRPA	x	x	x	x	x		x	x	x	x		x	x
TSC		x		x								x	x
UCD - TERC	x			x	x					x		x	x
UNR	x				x					x		x	x

* Acronyms listed on Page iv; See Appendix A for more detailed descriptions

1.3 GAPS AND CHALLENGES

The unique ecological and political landscape of the Lake Tahoe Region presents some policy challenges that could limit the ability of resource managers to achieve management goals. For example, the Nevada Department of Environmental Protection (NDEP) allows for the application of U.S. Environmental Protection Agency (EPA) – approved aquatic herbicides for the control of nuisance aquatic plants. On the California side of Lake Tahoe, however, the LRWQCB's regionwide water quality objectives for pesticides, and related objectives for nondegradation and toxicity, essentially preclude direct discharges of pesticides such as aquatic herbicides (see Appendix A). The LRWQCB is currently developing a Basin Plan amendment to consider proposals for the application of aquatic pesticides in the Region.

With respect to the inspection of AIS vectors (e.g., motorized watercraft, kayaks, waders, et cetera), it is the responsibility of each boat launch facility to provide inspectors. CDFG staff may inspect, impound or quarantine any conveyance (e.g., watercraft) that may carry dreissenid mussels (F & G Code §§ 2301). NDOW may seize as evidence any watercraft or other equipment *only if* probable cause exists to believe that a state listed prohibited species is being imported into, transported through or possessed in Nevada (NAC 503.110). TRPA-designated inspectors inspect all vessels launching at public and private boat ramps (Appendix B). Users of day-use recreation facilities (e.g., campgrounds); however, are subject to an AIS screening process for small watercraft where such sites are managed and staffed by special use permittees. Appendix C summarizes the USFS-LTBMU's AIS screening process for small watercraft, which is part of operating plan direction for special use permits.

CDFA operates 16 Border Protection Stations (BPSs) statewide to reduce the number of pest introductions to the state. Two BPSs are location in the Lake Tahoe Region: the Meyers Border Station, located in El Dorado County on U.S. Hwy 50 south of Lake Tahoe, and the Truckee Border Station, located in Nevada County on U.S. Hwy 80, five miles east of Truckee, California. Both stations currently operate 24 hours per day, seven days a week and inspect both commercial and private vehicles. Unfortunately, the stations are of limited effectiveness in preventing AIS from entering Lake Tahoe. Both stations are only structured to inspect west-bound traffic and the Meyers station is southwest of the Region. The Truckee station is located such that it inspects vessels that arrive at Lake Tahoe by way of Hwy 80, but many boats arrive from the east by other routes. The result is boaters arriving to Lake Tahoe from any direction can easily by-pass both BPSs. Conversely, west-bound boaters *leaving* Lake Tahoe are likely inspected.

1.4 PLAN OVERSIGHT

Oversight for *state* AIS management plans is typically led by a respective state resource agency (e.g., CDFG for the CAISMP); however, in the case of bi-state or regional plans, oversight is best suited to an organization capable of regulation across state jurisdictions. The TRPA, as created by California, Nevada, and the U.S. Congress has such regulatory authority (P.L. 96-551, 94, Stat. 3235). TRPA has successfully demonstrated the ability to cooperatively lead and manage the $1.1 billion Environmental Improvement Program (EIP). Therefore, the TRPA will act as the fiscal agent, or pass-through agency, for funds associated with implementing this Plan.

Efforts to improve collaboration, leverage funding, and provide peer oversight in the Region are implemented by members of the LTAISWG and/or the LTAISCC. The mission of the LTAISWG is to protect the Lake Tahoe Region from aquatic invasive species by education, research, prevention, early detection, rapid response, and control. The LTAISWG is comprised of resource managers, non-governmental organizations, researchers, and community members (Appendix D) whose participation is ratified through a Memorandum of Understanding (Appendix D, Attachment A). The LTAISCC provides direction for implementation of the Plan, and members ensure that the activities proposed in the Plan are either consistent with current agency policy or working in-house to expand or modify policies and management strategies to implement AIS activities (Appendix D, Attachment B). The LTAISCC is comprised of leaders from state and federal agencies, researchers, and other groups responsible for management, regulatory, or cultural heritage activities in the Region. TRPA staff currently participate in both the LTAISCC and the LTAISWG.

2 AIS Management Approach

The approach to managing AIS depends on a range of factors including, the species of concern, local and regional extent of infestation, likelihood of introduction, harmful impacts, and the cost and feasibility of control/eradication. The Aquatic Nuisance Species Task Force (ANSTF) recognizes five AIS management approaches, implemented independently or in combination:

- Prevention
- Monitoring
- Control/Eradication
- Education
- Research

2.1 PREVENTION

Prevention measures are used to address AIS not yet present as well as to diminish harmful impacts by reducing further spread. Prevention measures include activities such as inspection, quarantine and decontamination of watercraft, enforcement of legal authority, and strengthening the code of conduct for businesses dealing with aquatic organisms (Lodge et al. 2006). Inspection and decontamination of recreational equipment such as watercraft (including boats, rafts, kayaks, and float tubes), fishing gear, clothing, waders, rope, cooling tanks and live wells prevents the spread of many AIS such as dreissenid mussels, aquatic plants, and other unwanted pests.

Preventing the introduction of AIS to new waterbodies is most desirable and, fortunately, far more cost efficient compared to control efforts (Figure 1) (Leung et al. 2002; Lodge et al. 2006). Conversely, the likelihood of eradicating AIS is dramatically reduced once the population(s) is widely established.

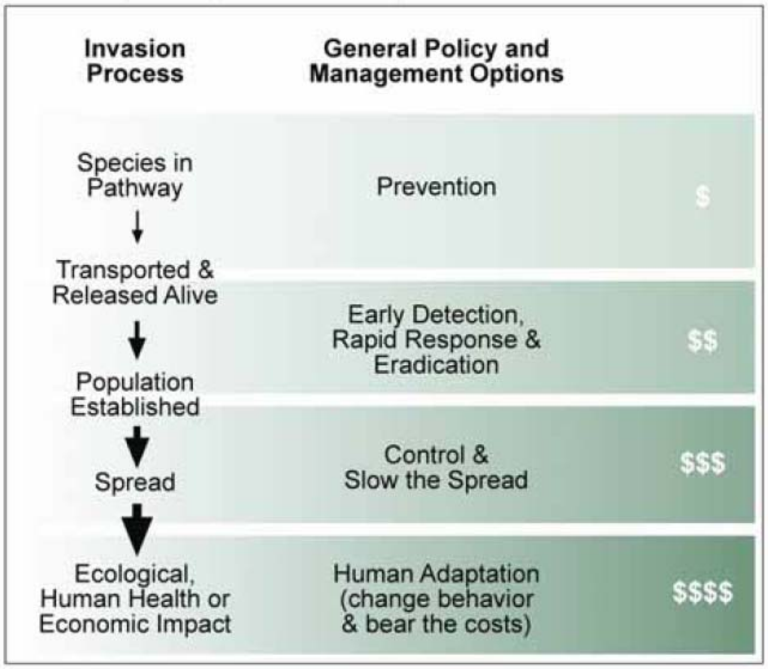

Figure 2. Model of Increasing Costs Based on Invasion Process and Management Response. From CDFG (2008) as Adapted from Lodge et al. 2006.

2.2 MONITORING

In addition to preventing the introduction of new AIS, surveying for new infestations and determining environmental thresholds improves success in control or eradication efforts. That is, early detection of new species allows for more effective rapid response outcomes such as quarantine and eradication, and more information on species distribution and biology leads to improved management with reduced impacts to native species. In Lake Tahoe, biologists are monitoring movement and spawning habits of warm water fishes in and around the Tahoe Keys to facilitate and improve control efforts and ameliorate their impacts to native species (Chandra et al. 2009). The distribution of aquatic plants are mapped yearly to monitor their spread around Lake Tahoe.

2.3 CONTROL/ERADICATION

The identification of new infestations often sparks the most attention and commands immediate resources to control or eradicate the invaders. Control of AIS implies that populations are present and small enough to curtail further increases while eradication involves complete removal of the species from an area. Factors to consider when evaluating the feasibility of control or eradication measures include:

- Size of infestation (i.e., small or new populations targeted for eradication with large infestations targeted for control)
- Demonstrated history of eradication elsewhere
- Knowledge of species life history
- Potential environmental impact
- Financial support for initial and follow-up management
- Likelihood of reintroduction
- Public comment
- Current policy restrictions

Well-coordinated efforts and the availability of approved control tools increase the likelihood of a successful eradication; however, this likelihood decreases substantially as the population spreads and becomes more abundant.

Numerous methods to manage AIS are briefly summarized in the Plan and are commonly presented as independent methods (e.g, physical removal of unwanted aquatic vegetation). Integrated Pest Management (IPM), however, combines a variety of management techniques utilizing an ecosystem-based approach in order to minimize impacts to human health, the environment, non-target species, and the economy. IPM efforts may include simultaneous management methods, monitoring, and research that in the end may result in reduced pesticide use and cost (Ehler 2006). An example of IPM might include the use of a biocontrol agent to reduce vegetation followed by mechanical or manual harvesting and a benthic/benthic barrier (described in Section 3.3 Aquatic Plants).

Efforts are currently underway in Lake Tahoe to control invasive aquatic plants (Eurasian watermilfoil and curlyleaf pondweed) and research is being conducted to determine the most effective means of controlling Asian clams and warm water fishes. The control measures in use or being investigated are not presently aimed at eradication; however, these objectives may change based on research outcomes.

2.4 EDUCATION

Education is key to any effective prevention program. Programs to educate the public about the impacts of AIS, methods to prevent introduction and further spread in the Region, and control efforts are actively underway by several organizations (Appendix D). Based on the USFWS's Stop Aquatic Hitchhikers! campaign, the message "Clean, Drain and Dry" is now common to visitors at Lake Tahoe. The Tahoe Resource Conservation District (TRCD) delivers the campaign logo and slogan through flyers, regulatory boat launch signs, koozies, training materials, highway billboards, television advertisements, and brochures. Most importantly, the message is reinforced by watercraft inspectors at boat launches. The CDFG produced a downloadable Quagga "Not Wanted" flyer (see Appendix D for internet link) that can be printed and posted at additional locations.

Other education/outreach activities currently used in the Region have included television advertisements, newspaper articles, the Tahoe Aquatic Nuisance Species Hotline (1-888-TAHO-ANS), the USFWS hotline (877-STOP-ANS), watercraft inspection trainings, presentations to public interests groups (e.g., public utility districts, chambers of commerce, property owner associations), and over Memorial Day weekend 2008, the use of CDFG's detection dogs, trained to detect quagga and zebra mussels based on odors.

2.5 Research

Research to enhance the understanding of AIS life histories, environmental thresholds, distributions, and interactions with native species is a critical component to the AIS management framework. This information allows for more effective and efficient IPM and results in reduced impacts to desirable species. Current research efforts in the Region include:

- Evaluating the effectiveness of physical removal methods such as diver-assisted suction in combination with benthic/bottom barriers to remove Asian clams
- Tracking warm water fish movement in and around the Tahoe Keys
- Determining quagga mussel survivability under low calcium conditions
- Monitoring aquatic plant distribution

2.6 Adaptive Management

Application of these management approaches may occur singularly (e.g., control/eradication) or in combination (e.g., prevention and education). Either way, managers and researchers must continually refine their approaches, through adaptive management, to improve effectiveness. That is, through an iterative process, reduce uncertainty, maximize resources, and improve the efficacy of the management approach.

Adaptive management strategies should be utilized for future Plan revisions. In particular, the effects of climate change on AIS should be considered as new information emerges from research and observations or monitoring (Bierwagen et al. 2008). Also, given the limited dollars that must be spread between all management approaches, it is important to evaluate the effectiveness of each. For example, researchers with the University of Minnesota Sea Grant Program found that after the Stop Aquatic Hitchhikers! campaign prevention message was reinforced through a variety of media, such that, boater/angler AIS awareness in Minnesota, Wisconsin, and Iowa improved dramatically as did the likelihood of taking precautionary actions (Doug Jensen, Minnesota Sea Grant, personal communication July 24, 2008). Overall, they found that information personally conveyed by watercraft inspectors at boat launches provided the most effective means of increasing AIS awareness and eliciting changes in behavior (i.e., removing AIS from trailered watercraft). This was followed by billboards and signs, targeted to non-residents in a timely manner (e.g., during holiday travel season).

3 Problem Definition and Ranking

Established and expanding populations of non-native aquatic plant and animal species are present in Lake Tahoe (Jassby et al. 2001). While some were intentionally and legally introduced, many were most likely introduced via recreational activities (e.g., boating) (Padilla et al. 1996, Johnson et al. 2001) or aquarium dumping. New and expanding populations of AIS to the Region threaten the ecological, aesthetic, and economic services so widely enjoyed. In fact, the potential economic impacts of a quagga or zebra mussel infestation at Lake Tahoe are estimated at over $22 million per year (Appendix E).

The following sections provide a background of species introductions to the Region, pathways of introduction, a brief discussion of their impacts, and a system for ranking species for management purposes. More detailed descriptions of species life histories, distribution, and control methods are proved in Appendix F.

3.1 Background

Human activities such as logging, grazing, urban development, and dam construction have occurred since the mid-1850s and have resulted in profound ecological changes to the Region including loss of biological integrity, decreased water quality, and increased fire hazard (USDA 2000, LRWQCB and NDEP 2007, Chandra et al. 2009, Raumann and Cablk 2008). To address many of these concerns, numerous programs and policies are being developed or have been implemented, for example:

- Environmental Improvement Program (EIP)
- *Regional Plan* (TRPA 2008)
- *Land and Resource Management Plan* (USFS)
- Draft total maximum daily load (TMDL) regulations for Lake Tahoe (Lahontan Region Water Quality Control Board [LRWQCB] and Nevada Division of Environmental Protection's [NDEP])
- Shorezone Ordinances (TRPA)
- *Water Quality Management Plan for the Tahoe Region* (208 Plan; TRPA)

Prior to the 1800s, the trophic structure of Lake Tahoe was relatively simple and limited to one predatory fish population, the native Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) which is now extirpated from the lake. The demise of the Lahontan cutthroat trout from the Tahoe Basin is largely attributed to predation by lake trout, or mackinaw (*Salvelinus namaycush*) (introduced to Lake Tahoe for sport-fishing in 1888 [Cordone and Frantz 1966]) and by hybridization with non-native species of rainbow trout (*Oncorhynchus mykiss*). Other factors which contributed to the decline include: overexploitation by humans, dam construction on the Truckee River which prevented the migration of fish, and loss of spawning habitat (USFWS 1995 and summarized in Vander Zanden et al. 2003). Today, the historical trophic niche of the Lahontan cutthroat trout in Lake Tahoe is now occupied by lake trout (Vander Zanden et al. 2003).

The establishment of lake trout and mysid shrimp (*Mysis relicta*) (intentionally introduced in 1963 for game fish forage) (Linn and Frantz 1965) also coincided with declines in native Lahontan redside (*Richardsonius egregius*) and speckled dace (*Rhinichthys osculus*) populations (Chandra et al. 2009) from the Tahoe Keys, an important rearing ground for native fishes (CDFG, unpublished data). Mysid shrimp have contributed to the shift in the Lake Tahoe's trophic structure and composition. For example, predation by mysid shrimp have played a significant role in the loss or near elimination of three pelagic cladoceran (small crustaceans) species from Lake Tahoe with an occasional reappearance during years of increased productivity (Richards et al. 1975, Goldman 1979, Byron et al.1984). Furthermore, other fish species have shifted their feeding from benthic to pelagic fish production due to the influence of mysid shrimp (Vander Zanden et al. 2003).

More recent AIS introductions to Lake Tahoe include non-native warm water fish (largemouth bass and bluegill), aquatic plants (Eurasian watermilfoil and curlyleaf pondweed) and invertebrates (Asian clams). Many of these AIS are found within isolated areas of Lake Tahoe (e.g., marinas and embayments) and in the Tahoe Keys. In fact, the largest populations of AIS are found in or near the Tahoe Keys along the south shore; however, populations are present and rapidly expanding to other regions of Lake Tahoe. Efforts to identify expanding populations are currently underway by numerous researchers from the LTAISWG.

The January 2007 confirmation of quagga mussels in Lake Mead, Nevada marked the first population of dreissenid mussels west of the 100th Meridian. This population also served as a wake-up call to resource managers, researchers, boaters, and marina operators throughout the Region because boats are commonly trailered between Lake Mead and Lake Tahoe (Wittmann 2008).

3.2 Pathways of Introduction

While AIS can be transported naturally, for example, seeds can be transported on currents and fish can move up and down streams; human activities are a common vector for transporting AIS.

Thus, the potential for AIS colonization depends as much on suitable environmental conditions as the frequency the waterbody is exposed to human activities. Unwanted species hitchhike via a myriad of human-driven pathways including recreational activities, the aquarium trade, commercial shipping, intentional stocking, and resource management activities (Cooke et al. 2005, CDFG 2008). The potential for new AIS introductions is especially worrisome as boats arrive to the Region from AIS-infected water bodies such as Lake Havasu, Lake Mead, and the Colorado River Basin (Wittmann 2008). For example, in August 2008 a mussel-contaminated boat was intercepted and quarantined prior to launching at Lake Tahoe.

Recreational Activities

Recreational activities involving watercraft (including motor boats, personal watercraft, kayaks, canoes, float tubes, et cetera) and/or fishing are the most likely vectors for the introduction of AIS to the Region (inter-Region) and among waterbodies within the Region (intra-Region). Currently, TRPA Code 79.3 B(2) states that "all watercraft, motorized and non-motorized, including but not limited to boats, personal watercraft, kayaks, canoes and rafts, shall be subject to an inspection prior to launching into the waters of the Lake Tahoe Region to detect the presence, and prevent the introduction, of aquatic invasive species". While the establishment of AIS is largely determined by factors such as environmental conditions, food availability, and the presence of predators, the movement of AIS between waterbodies is determined by similarities in recreational pursuits, possibly even more than waterbody proximity. For example, the likelihood may be greater that New Zealand mudsnails (*Potamopyrgus antipodarum*) would be introduced from one fly-fishing stream to another (from fishing gear such as float tubes, felt-soled waders) rather than a fly-angler introducing mudsnails to Lake Tahoe. Conversely, a power boat contaminated with quagga mussels would not be the most likely vector for mussels to a lake without a boat launch.

Inter-Region AIS Introductions

During the 1998 boating season, there were approximately 99,300 power boat trips from launches at Lake Tahoe (Hagler-Bailly 1999). Most AIS exposure to Lake Tahoe is due to recreational boats that are more likely to move between waterbodies with similar recreational opportunities rather than smaller waterbodies that may be closer. During the summers of 2005 and 2006, Wittmann (2008) conducted recreational boater surveys at seven boat launches around Lake Tahoe. Boaters were asked about their boat use, visitation frequency, areas visited at Lake Tahoe, cleaning practices/habits, and AIS awareness. A visual inspection was also conducted. Of the 778 boaters surveyed, about 300 users had visited about 20 other waterbodies within a week (some of which are listed in Table 2). During the same survey, Wittmann found that 265 boats originated from waters with AIS and that three of those waterbodies contained quagga mussels (Lake Mead, Colorado River, and Lake Havasu). She also found that 117 boats that were leaving Lake Tahoe had aquatic plants (native and non-native) entrained on boating equipment when exiting the lake and that 82.1% of boaters surveyed "never" conduct as much as a visual inspection of their equipment for AIS after use.

Table 2. Inter-Region Recreational Waterbodies

Waterbody	Boat Launch	Fishing	Non-motorized	Rafting
Inter-Region Waterbodies				
Lake Berryessa, CA	x	x	x	
Boca Reservoir, CA	x	x	x	
Colorado River, NV	x	x	x	x
Donner Lake, CA	x	x	x	
Folsom Lake, CA	x	x	x	
Lake Havasu, AZ	x	x	x	
Lahontan Reservoir, NV	x	x	x	
Lake Mead, NV	x	x	x	
Pyramid Lake, NV	x	x	x	
Sacramento-San Joaquin Delta, CA*	x	x	x	
Lake Shasta , CA	x	x	x	
Stampede Reservoir, CA	x	x	x	
Topaz Lake, CA-NV	x	x	x	
* At least 84 non-native species are found in the freshwater portions of the San Francisco Bay and Delta ecosystem; Source: Cohen and Carlton. 1998.				

Intra-Region AIS Introductions

In addition to Lake Tahoe, seven other important recreational waterbodies are located in the Region (Table 3). These waterbodies not only provide further opportunities for AIS introduction *to* Lake Tahoe but they risk invasion by Eurasian watermilfoil, curlyleaf pondweed and Asian clams *from* Lake Tahoe.

Table 3. Intra-Region Recreational Waterbodies

Waterbody	Boat Launch	Fishing	Non-motorized	Rafting
Lake Tahoe, CA-NV	x	x	x	
Cascade Lake, CA		x	x	
Echo Lake, CA	x	x	x	
Fallen Leaf Lake, CA	x	x	x	
Incline Lake, NV		x		
Lower Truckee River, CA*	x	x	x	x
Marlette Lake, NV		x		
Spooner Lake, NV		x	x	
*Only the first 6 km of the Lower Trucker River below the dam at Lake Tahoe is considered in the Lake Tahoe Region				

Cascade Lake lies south of Emerald Bay and has no public boat launch and much of the shoreline access is privately held. Echo Lake, south-west of South Lake Tahoe, has a public boat launch operated by Echo Lake Chalet under a USFS-LTBMU special use permit. The gated boat launch is closed when a trained inspector is not available. Game fishes present in Echo Lake include rainbow, brook and Lahontan cutthroat trout. Most of the shoreline at Fallen Leaf Lake is publicly held by the USFS-LTBMU. From the northern shore of Fallen Leaf Lake, Taylor Creek runs directly to Lake Tahoe. Game fishes present in Fallen Leaf Lake include lake, rainbow, Lahontan cutthroat, brook and brown trout and Kokanee. Incline Lake is on the Third Creek drainage, located between Mount Rose and Incline Village on the north side of Lake Tahoe. The lake, along with the 750 acres surrounding it, was controlled by the Incline Lake Corporation until summer 2008 when ownership was transferred to the USFS-LTBMU. The land will be jointly managed by the USFS-LTMBU and the USFS-Humboldt-Toiyabe National Forest. Many of the 63 streams that drain to Lake Tahoe are popular for recreational activities, including fishing and rafting. Only the first 6 km of the Lower Truckee River is technically considered in the Lake Tahoe Region; however, its popularity for rafting and fly fishing leave it particularly vulnerable to New Zealand mudsnail introduction and establishment. Marlette Lake, located in the Lake Tahoe Nevada State Park northeast of Lake Tahoe, is closed to motorized watercraft. Game fishes in Marlette Lake include brook trout, Lahontan cutthroat trout, and rainbow trout. The lake is currently managed as a brood lake for rainbow and cutthroat trout which provide eggs for NDOW hatcheries. Spooner Lake, south of Marlette Lake and also in the State Park, has no boat launch facilities but is open to catch and keep trout fishing with a five trout limit. Due to their limited or restricted boat access, Marlette and Spooner Lakes may be at greater risk of AIS introduction via contaminated waders and float tubes.

Aquascaping and the Aquarium Trade

The use of aquatic plants in outdoor water features is increasing in popularity. Many species associated with this industry are non-native to the U.S. and often problematic in natural environments. Increasing internet sales have facilitated the widespread distribution of many federal and state listed prohibited species (Kay and Hoyle 2001). Education and outreach efforts directed to the aquascaping and aquarium trades have increased. Programs such as the ANSTF's partnership program, Habitattitude™, and Sea Grant campaigns encourage the selection of non-invasive or regionally native plants and the construction of water features away from natural waterways. Despite these efforts, the spread of invasive aquatic plants continues, most likely due to lack of enforcement or inadequate stewardship.

Dumping of non-native live bait is prohibited in Lake Tahoe, a measure that most likely prevents the further spread of unwanted fish species. The use of live bait in Lake Tahoe and its tributaries in Carson City and Douglas and Washoe Counties is only allowed for the following species: Lahontan redside shiner, tui chub (*Gila bicolor*), Tahoe sucker (*Catasomus tahoesis*), Lahontan mountain sucker (*Catostomus platyhynchus*), Paiute sculpin (*Cottus beldingii*) and Lahontan speckled dace (NDOW 2008). Fish used as live bait may only be taken from, and must be native to, Lake Tahoe and its tributaries.

Resource Management Activities

Many non-native species are intentionally introduced, but others are unintentionally introduced through resource management activities such as fish stocking or habitat enhancement projects. Hitchhikers in early development stages (i.e., egg, larvae, or seed) can easily be transported on equipment (e.g., water sampling devices, nets, waders, and shovels) or in water (e.g., fish enhancement projects, revegetation projects for riparian or submersed vegetation) by unknowing workers.

Nearshore Construction Activities

Shoreline construction and maintenance activities such as the removal, replacement or repair of docks, moorings, marinas, and other structures may result in the introduction of harmful AIS if contaminated equipment is used. Again, TRPA Code 79.3 B(2) requires all watercraft, motorized and non-motorized, be inspected prior to launching into the waters of the Region. Thus, inspection and decontamination requirements are extended to construction equipment.

Wildfire Suppression Activities

Wildfires threaten not only the forest ecosystem of the Region, but homes and commercial structures. The Angora Fire, located in the southwestern portion of the Region, burned over 3,000 acres, nearly 300 homes and 67 commercial buildings in 2007. To control these fires, the USFS-LTBMU and other private and state firefighters commonly use aerial and ground-based drafting/dipping methods from nearby waterbodies. This involves the use of water conveyance equipment including: slings, buckets, suction hoses, and holding tanks to remove and transport water to fires. The USFS-LTBMU developed Resource Guidelines for Wildfire Suppression to help conserve natural resources, including reducing the likelihood of AIS transport from fire suppression activities. The AIS pertinent guidelines include:

- Decontaminate water conveyance equipment (slings, buckets, suction hoses, holding tanks) before and after use. Disinfect internal tanks by applying either a rinse of 5% solution of Quat 128 or Sparquat 256 or high pressure water applied at 140 degrees F or hotter. Do not pump treated water into any stream or lake, or on areas where it can migrate into any waterbody.
- Remove water at least 1000 ft. from the shoreline in Lake Tahoe and 500 ft. from the shoreline in Emerald Bay in order to avoid coming in contact with aquatic weeds (Eurasian watermilfoil and curlyleaf pondweed) from water withdrawal equipment (i.e., buckets and/or suction hoses).
- Only remove water out of 1 site once committed to a specific water body unless conveyance systems are decontaminated before removing water from an alternate site.

For management consistency, these AIS fire suppression guidelines are available for use by other state, county and municipal agencies who have responsibility for wildfire suppression. The important consideration for wildfire suppression is, where possible; avoid removing water from areas with known AIS, such as Eurasian watermilfoil and curlyleaf pondweed.

3.3 Non-native Species Present or Threatening Lake Tahoe

At least 20 known non-native aquatic species, including plants, fish, invertebrates, and an amphibian are established in the Region. Many of these non-native species were purposefully and legally introduced (i.e., as a managed game fishery), but others were introduced illegally, for example, through recreational activities, the aquarium trade, or resource management activities such as habitat enhancement projects.

Aquatic Plants

Dense growth of invasive aquatic plants impede water flow, disrupt navigation, discourage recreational activities, deleteriously affect water quality, and reduce plant diversity (Smith and Barko 1990, Frodge et al. 1991, Boylen et al. 1999, Mullin et al. 2000). Non-native aquatic plants known to occur in Lake Tahoe include Eurasian watermilfoil and curlyleaf pondweed. These rooted plants "pump" nutrients from the sediment to the overlying water column (Carignan and Kalff 1980; Granéli and Solander 1988; Walter et al. 2000) during growth and may be contributing to increased phytoplankton and reductions in water clarity at Lake Tahoe. The ability of a plant to spread and become invasive is strongly driven by factors such as its propagule type (e.g., seed, stem fragment, tuber, turion, stolon, rhizome), propagule number, and ability to withstand harsh conditions and optimize limited resources (e.g., light and nutrients) (Haynes 1988).

Eurasian watermilfoil was likely introduced to Lake Tahoe in the 1960s to early 1970s when the Tahoe Keys were developed; however, paleolimnological data do not fully support this (Kim and Rejmánková 2001). The U.S. Department of Agriculture–Agricultural Research Service (USDA-ARS) confirmed Eurasian watermilfoil in Lake Tahoe in 1995 and curlyleaf pondweed in 2003 (Anderson 2007) (Figure 3). Both populations are concentrated in the south basin, near the Tahoe Keys. As of 2006 the range of curlyleaf pondweed had extended northeastward to the Lakeside Marina (Anderson 2007) and, as recently as summer 2008, coverage in the Tahoe Keys had expanded substantially (Lars Anderson, USDA-ARS, personal communication, June 3, 2008). While native plant species such as Andean milfoil (*M. quitense*), Canadian waterweed (*Elodea canadensis*), coontail (*Ceratophyllum demersum*) and leafy pondweed (*Potamogeton foliosus*) are found in Lake Tahoe, Eurasian watermilfoil and curlyleaf pondweed dominate the submersed aquatic plant community (Anderson 2007). Surprisingly, prior to 1995, only one published reference to "*Myriophyllum* sp." (near Ward Creek and Tahoe City) has been documented (Flint and Goldman 1975) and all other evidence for aquatic plant distribution and species is anecdotal (Lars Anderson, USDA-ARS, May 14, 2009).

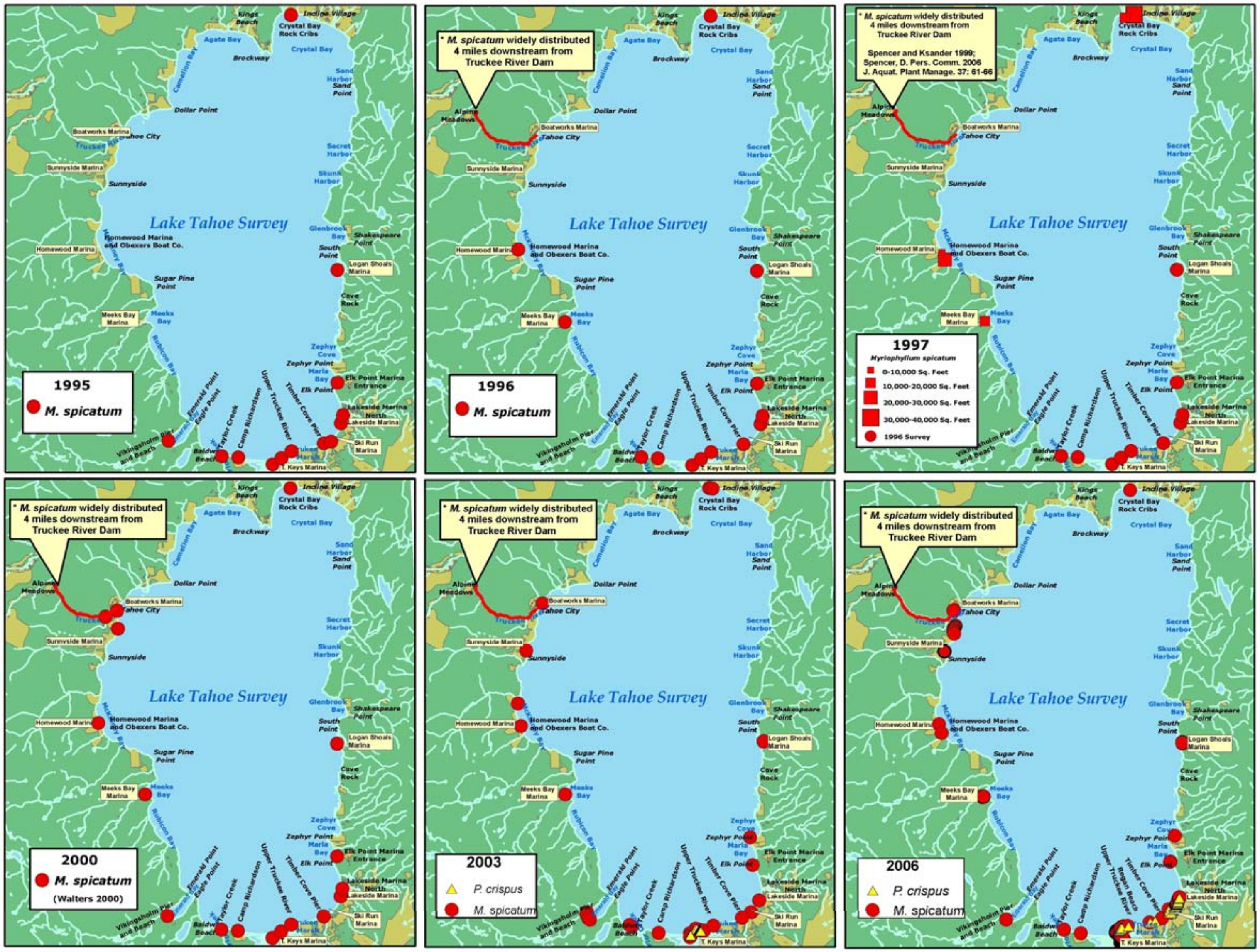

Figure 3. Distribution of Eurasian watermilfoil (*M. spicatum*) and curlyleaf pondweed (*P. crispus*) in Lake Tahoe from 1995 to 2006 (Anderson 2007)

Factors such as light penetration, wave energy, sediment texture, slope, and water temperature all influence submersed plant distribution (Duarte and Kalff 1986, Hudon et al. 2000). Depth information at Lake Tahoe has been shown to be the most comprehensive variable (i.e., easily mapped and readily available information) for predicting plant distribution. To determine the potential habitat available for submersed aquatic plants, we assumed a survival depth of approximately 11 m (Sheldon and Boylen 1977, Chambers and Kalff 1985, Schwarz and Howard-Williams 2000). This represents the maximum depth under most natural conditions. Within this depth range, there are approximately 4,600 surface hectares of available habitat for submersed aquatic plants in Lake Tahoe, including the Tahoe Keys area (Figure 4). Areas of high energy (due to wind and waves), steep slopes, and poor substrate such as large boulders (e.g., north of Cave Rock to South Point, entrance to Emerald Bay) are unlikely to support submersed plant growth, regardless of depth. Conversely, the leeward (west side) and isolated embayments and marinas are more likely to support aquatic plant growth. More research is needed to better quantify the potential distribution of aquatic plants in Lake Tahoe.

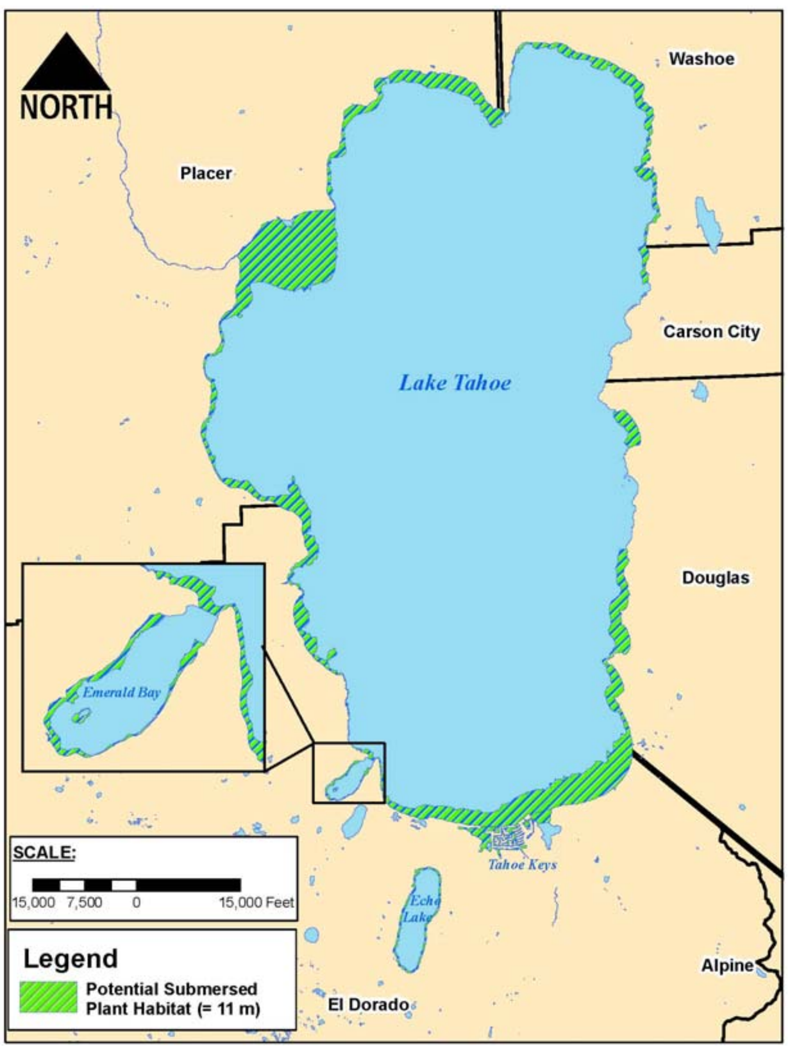

Figure 4. Potential distribution of submersed plants (e.g., curlyleaf pondweed and Eurasian watermilfoil) in Lake Tahoe

Control/Eradication Methods for Invasive Aquatic Plants

Controlling or eradicating unwanted aquatic vegetation may be accomplished using the methods outlined below or through IPM. The following sources were consulted to summarize aquatic plant control technologies: Gibbons et al. (1999), Madsen (2000), Cooke et al. (2005), and Washington Department of Ecology (2008).

Physical and Cultural Methods

Methods to physically control unwanted aquatic plants include: hand-pulling and hand-pulling with diver-assisted suction, deployment of benthic/bottom barriers, water level drawdown, and the use of tools such as cutters, rakes, or hooks. Many of these physical methods; however, typically produce plant fragments capable of sprouting.

Diver-operated suction is used to facilitate the removal of plants and plant fragments following hand-pulling. Similar to vacuuming, the plant material and sediment are suctioned during hand-pulling then transported to the surface. The sediment is sifted through a screen and the vegetation is retained for disposal. This method can allow for selective removal of unwanted vegetation, may be used near boat docks, and is environmentally favorable. Increased turbidity can temporarily result from diver-assisted suction, and reduce diver visibility. While an effective means of controlling invasive aquatic plants, vegetative hibernacula such as tubers, turions, and root crowns may remain in the sediment allowing for reinfestation.

Hand-pulling of aquatic plants is most effective in shallow water where the bottom is within reach. In deeper water, tools and/or snorkel or SCUBA gear will most likely be needed. Physical methods of plant removal are best for smaller areas as it is very labor intensive. Because plant fragments form using many physical methods, it is important to have a system in place to contain the fragments (e.g., suction device, booms around the boat, person to hand net the fragments, et cetera), and have an off-site location for disposal away from water sources.

Benthic/bottom barriers, also called benthic screens, control rooted aquatic plants by covering the vegetation with materials such as sand, gravel, burlap, plastic, or woven synthetic fibers thereby preventing light penetration. These barriers can be used at various depths but will most likely require divers for many applications, for example in deep water or around boat docks and piers. Flexible, non-porous materials require anchoring due to gas buildup from decomposing plant material.

The advantages of bottom barriers are that a variety of rooted plants, particularly new infestations may be controlled and they are considered environmentally favorable. Disadvantages include maintenance, cost of material, limited to flat areas or those with little change in slope and no obstructions (i.e., logs, boulders, large rocks, et cetera), and cost of installation if commercial services are used. Maintenance is critical as plants can send lateral branches from under the barrier, improper anchoring can lead to ballooning of the material, and sediment deposition over the barrier can exacerbate barrier decomposition (e.g., for burlap). Lastly, barriers may lead to temporary impacts to benthic organisms.

In general, the advantages of physical control methods are: they are inexpensive, allow for selective removal, are simple, and are environmentally favorable. Disadvantages for physical control methods are: labor intensive effort and plant fragments need to be removed to prevent further spread. Additionally, water may become turbid and limit visibility particularly when pulling plants that have large or deep rhizomes or roots. Operations may require acquisition of permits and water quality monitoring for diver-assisted suction removal and bottom barrier placement and removal. Monitoring needs are likely to be evaluated on a case by case basis by the LRWQCB.

Water level drawdown may be used to expose plants to extreme desiccation, heat, or cold long enough to kill them. Water drawdown may be more acceptable than chemical control and provide opportunities for maintenance of other structures such as boat docks, fish screens, dams or installing bottom barriers. Frequent and/or prolonged drawdowns are often required for substantial reduction or elimination of unwanted vegetation. Water drawdown is not a selective plant eradication strategy and may encourage the growth of unwanted vegetation, particularly plants that can survive desiccation (e.g., hydrilla tubers [Doyle and Smart 2001]). This method of plant control is more applicable for use in reservoirs, irrigation canals and other areas where water level control structures are present and is not considered a viable method for controlling invasive aquatic plants in Lake Tahoe.

Mechanical Methods

Mechanical control devices typically “mow” the upper portions of a plant canopy (up to about 1-2 meters. below the water surface) using a mechanized cutter. The scale of mechanical controls ranges from portable boat-mounted to barge-like devices. Fragment recovery is critical to prevent further spread and can be accomplished using a net for boat-mounted devices. For larger harvesters, a conveyor belt system may be used to offload harvested vegetation to a barge where plants are deposited on shore or contained for transport off-site.

The advantages of mechanical control are that open water access is immediately provided and it is environmentally favorable. The disadvantages are that cost varies greatly between small boat-mounted cutters and large-scale harvesters. The latter have to be either transported from elsewhere, or purchased for use within the same waterbody. The prevailing disadvantages are that plants are allowed to return, there is no selective control, and plant fragments can be released and expand the in-lake population.

Weed cutting and harvesting are not currently regulated in the Region, however there are concerns about the improper disposal of plant fragments that could spread infestations and release nutrients upon decay. Additionally, the operation and maintenance of weed harvesters should be sufficient to prevent leakage of mechanical fluids. Regulatory agencies (i.e., LRWQCB or TRPA) *may* require that a plant disposal plan and an operations and maintenance plan be in place prior to project commencement.

Biocontrol Methods

Biocontrol is the use of one organism (generally host-specific) to control another. The control agent works by impacting the reproduction or growth of the host. Because the presence of the host organism is required for the biocontrol agent, this method used alone will provide control, but not eradication. Biocontrol methods may, however, be used as part of an IPM plan to increase efficacy.

The advantage of biocontrol agents is that public perception is generally favorable and the perception is further improved when the proposed agent is native. Additionally, while biocontrol agents will not effectively eradicate unwanted vegetation, they can control plants to more acceptable levels, allowing for native vegetation to thrive or leave plants susceptible to other control methods using IPM. Biocontrol agent stocking rates are difficult to predict especially in novel environments.

The native North American weevil (*Euhrychiopsis lecontei*) has been shown to be an effective biocontrol agent against Eurasian watermilfoil (Newman et al. 1996, Creed 1998). Weevil larvae damage milfoil plants by mining through the stem during their development (Mazzei et al. 1999). The result can be substantial loss in stem and root biomass without the need for mechanical removal. The optimal stocking rate of weevils has been estimated at two to four weevils per stem (Newman and Biesboer 2000); however, damage to the plant depends on factors such as water temperature, disease, and plant health (Newman et al. 1998, Mazzei et al. 1999, Spencer and Ksander 2004). Weevils have been considered for use in Lake Tahoe; however, it is unlikely that viable populations of the insects would establish at Lake Tahoe due to lack of suitable over-wintering habitat, shoreline development, expense, and because Eurasian watermilfoil does not commonly reach the water surface (due in part to high boat traffic) (Lars Anderson, USDA-ARS, personal communication June 3, 2008).

Chemical Methods

Aquatic herbicides registered by the United States Environmental Protection Agency (USEPA) may be used to control and in some cases, eradicate unwanted vegetation. Herbicide selection is based on factors such as plant species, waterbody function (e.g., drinking water, recreation, aesthetics or irrigation), presence of native and/or federal/state listed species, public perception, and other considerations. Aquatic herbicides are typically discussed in terms of their mode of action and selectivity. Aquatic herbicides used to control curlyleaf pondweed and Eurasian watermilfoil include early season application of endothall (Netherland et al. 2000), or the use of diquat or fluridone (Table 4).

Disadvantages of chemical control methods include restrictions to swimming, drinking water, and fishing and potential impacts to non-target plants. Additionally, the use of chemical controls may require extensive water quality monitoring that could increase overall program costs. In the Lake Tahoe Basin, water quality objectives for pesticides, and related objectives for non-degradation and toxicity, essentially preclude direct discharges of pesticides such as aquatic herbicides (California Regional Water Quality Control Board Lahontan Region 2005; TRPA Water Quality Management Plan for the Tahoe Basin; see Appendix A).

Table 4. Aquatic Herbicides Registered in by California Department of Pesticide Regulation (CDPR), Nevada Department of Agriculture (NDA) and/or the U.S. Environmental Protection Agency (USEPA)

Active Ingredient	Controls	CDPR	NDA	USEPA
2, 4-D (butoxy-ethyl-ester [BEE])	Eurasian watermilfoil		✓	✓
2, 4-D (dimethylamine salt [DMA])	Eurasian watermilfoil	✓	✓	✓
Carfentrazone-ethyl	Eurasian watermilfoil		✓	✓
Copper (elemental)	Eurasian watermilfoil	✓	✓	✓
Copper (chelated)	Curlyleaf pondweed Eurasian watermilfoil	✓	✓	✓
Diquat dibromide	Curlyleaf pondweed	✓	✓	✓
Endothall (dipotassium salt)	Curlyleaf pondweed Eurasian watermilfoil	✓	✓	✓
Fluridone	Curlyleaf pondweed Eurasian watermilfoil	✓	✓	✓
Penoxsulam	Curlyleaf pondweed Eurasian watermilfoil	✓	✓	✓
Triclopyr (triethylamine [TEA])	Curlyleaf pondweed Eurasian watermilfoil	✓	✓	✓
Acid Blue 0 Acid Yellow 23	Curlyleaf pondweed Eurasian watermilfoil	✓	✓	✓

Resource managers at Lake Tahoe have employed various methods to reduce invasive aquatic plants, including physical, mechanical, and cultural. Physical methods have included diver-assisted suction and bottom barriers. Bottom barriers were installed at Lake Tahoe during the summer of 2008 - in a boat slip at Lakeside Marina, near the shoreline at Ski Run and in Emerald Bay. Post-treatment observations in Emerald Bay indicate few plants survived; however, the success of barriers in Emerald Bay is limited by diverse topography, boulders, logs, and other woody debris, such that hand-pulling and diver-assisted suction is required in many areas.

The Tahoe Divers Conservancy (TDC) recently began an Aquatic Plant Research Diver Certification with the objective of training divers to remove rooted vegetation in a manner that would minimize increases in turbidity from re-suspension of fines from the bottom substrate. Mechanical harvesting is used in the Tahoe Keys to remove Eurasian watermilfoil and curlyleaf pondweed. Four harvesters are operated 40 hours per week from June to October to control vegetation (Harry Dotson, TKPOA personal communication, July 10, 2008).

Long-distance water circulation systems (SolarBees) were installed in the east basin of the Tahoe Keys for about three years to reduce the impacts of Eurasian watermilfoil but have since been removed due to no perceived success and data are not readily available.

A study was conducted by researchers from the USDA-ARS using plants (Eurasian watermilfoil), sediments and water from Lake Tahoe (more specifically Tallac Lagoon). The purpose was to evaluate the efficacy of endothall, triclopyr, and fluridone in controlling Eurasian watermilfoil. They found that Eurasian watermilfoil from Lake Tahoe exposed to EPA-approved herbicides showed similar susceptibility to those test elsewhere in the U.S.

Warm Water Fishes

Beginning in the mid-late 1970s through the late 1980s, a variety of warm water fish species were found in the nearshore environment of Lake Tahoe (Reuter and Miller 2000). These illegal introductions are thought to be the result of anglers eager to catch these fish. Prior to that, native minnows were abundant while warm water fish were rarely found around the lake. By the late 1980s however, largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) were common to the Tahoe Keys. The change in fish structure was confirmed by fishing guides operating out of the Tahoe Keys. Within a decade they could no longer collect minnows, commonly used as bait during fishing charters, on the lake from certain marinas. The quick reduction in native fish abundance raised concern, while at the same time suitable habitat for non-native fishes in the nearshore environment increased (i.e., expansion of aquatic weed beds), further reducing food web efficiency and decreasing biodiversity of fish assemblages (MacRae and Jackson 2001).

Until recently, the distribution of warm water fishes beyond the Tahoe Keys was largely unknown, but a survey by Kamerath et al. (2008) found non-native fish species, including bluegill, largemouth bass, brown bullhead (*Ameiurus nebulosus*), black crappie (*Pomoxis nigromaculatus*), gold fish (*Carassius auratus auratus*), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*) at 12 of 21 sites around Lake Tahoe (Figure 5). It is believed that increased water temperatures have extended the amount of habitat available for warm water fishes to spawn (Chandra et al. 2009).

University of Nevada - Reno (UNR) and University of California – Davis (UCD) researchers recently investigated the distribution, relative abundance, and diets of warm water fishes within Lake Tahoe and, more specifically, whether they are moving out of the Tahoe Keys (Chandra et al. 2009). Additionally, they monitored temperature changes in the nearshore environment to determine where and when adequate spawning conditions are present. The objectives of their work were to determine whether the Tahoe Keys could serve as a source population of warm water fishes to the rest of the lake, and to identify management periods to reduce deleterious impacts to native fishes. Nearshore temperature data suggests that all monitored sites are thermally suitable for largemouth bass, bluegill, and likely other warm water fishes and that bass migrate out of the Tahoe Keys in early to mid summer. Based on the shift in largemouth diet to piscivory at two to four years (8.0 to 12.0 cm), Chandra et al. (2009) recommend largemouth bass removal, optimally every two years, to minimize predation pressure and competition with native fishes.

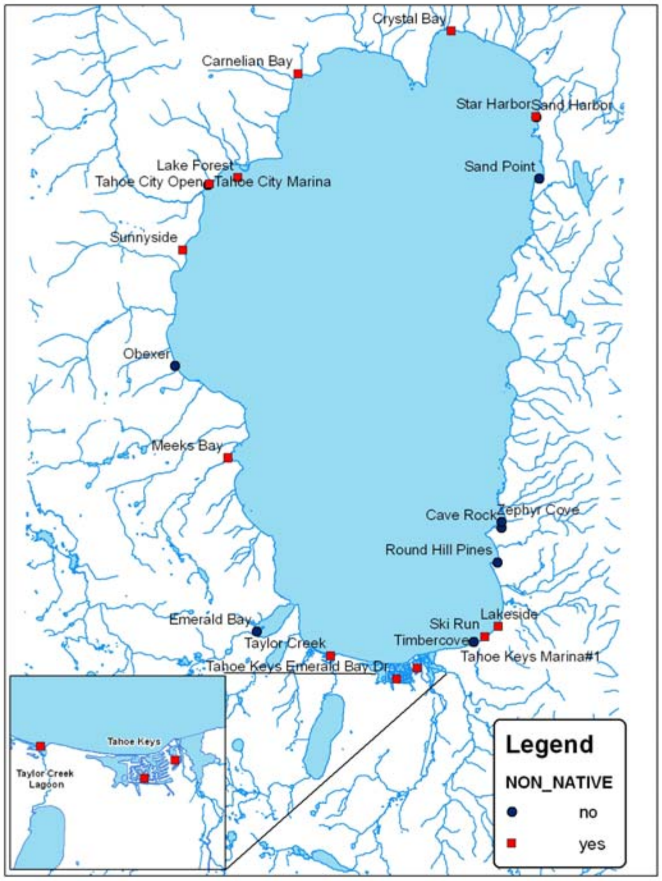

Figure 5. Survey locations with (indicated by "yes") and without (indicated by "no") non-native warm water fishes May-November 2006 (modified from Kamerath et al. 2008)

Control/Eradication Methods for Invasive Fishes

Examples of non-chemical methods to control unwanted warm-water fishes include, fyke nets, gill nets, or minnow traps. These efforts are more efficacious in smaller waterbodies and require repeat visits (Closs et al. 2003). Electro-fishing and seines may be used to control invasive fish, however evidence from Lake Davis, CA and Browns Pond, CA suggest these methods have limited impact, at least for controlling northern pike and grass carp, respectively. Biological control methods include increasing predators such as largemouth bass. Another method is harvest, as in Japan where the government is attempting to facilitate the eradication of bluegill from Lake Biwa, Japan by calling on its citizens to "catch-and-eat" the nuisance non-native species.

Chemical methods to control warm water fishes include the plant-derived piscicide, rotenone. Rotenone acts by inhibiting oxygen uptake through the gills, resulting in suffocation. Rotenone is non-selective, meaning it will kill all fish within the target tolerance level as well as other aquatic organisms such as invertebrates; however, there is usually recovery of benthic organisms over time (Mangum and Madrigal 1999; Melaas et al 2001). Different fish species can tolerate different levels of exposure thus application rates are based on target-species tolerance. Oftentimes, applications are made in combination with a significant drawdown or area isolation. Following rotenone application, potassium permanganate may be used to neutralize the effects of rotenone. Typically, a concerted effort is made to salvage as many native fish species as possible prior to the application of a piscicide.

At present, warm water fishes are not being controlled in Lake Tahoe; however, as part of Southern Nevada Public Land Management Act (SNPLMA) Round 8, 9, and 10 Capital Projects, research led by the Tahoe Keys Subcommittee (as part of the LTAISWG) will study the effects of experimental aquatic weed removal on localized warm-water fish populations. Target areas will be based on projections of overlapping habitat use by native fish species.

Given the evidence that largemouth bass migrate out of the Tahoe Keys and that widespread nearshore habitat is available for spawning, UNR and UCD researchers recommend that temperature monitoring at least once a week at marina and non-marina locations with the goal of targeting management activities to when movement and spread of non-native fishes are most likely to occur (Chandra et al. 2008). That is, removal efforts should precede maximum water temperatures in June and July to prevent spawning and spread of non-native fishes and follow up in October, or when water in marinas become colder than exposed, open-water sites, and fish move out into the warmer waters of the lake.

Rotenone use in Lake Tahoe is not currently prohibited per se, but applications must be reviewed on a case by case basis, meet a series of conditions, and are subject to approval by the Executive Officer of the LRWQCB. Simplification of this approval process, or easing of requirements, would require an amendment to the Basin Plan which is currently being evaluated.

Other Species

The establishment of non-native aquatic invertebrates and other vertebrates such as amphibians has the potential of severely impacting new environments. Invasive invertebrates present in Lake Tahoe include the Asian clam, signal crayfish (*Pacifastacus leniusculus),* mysid shrimp, and gill maggot (*Salmincola californiensis)* (Kamerath et al. submitted). Invasive invertebrates threatening introduction to the Lake Tahoe Region include quagga and zebra mussels, New Zealand mudsnails, and spiny Waterflea (*Bythotrephes longimanus)*. Bullfrog (*Rana catesbeiana*) is also present in the Region.

The Asian clam is a small (~1-25 mm) bio-fouling filter-feeder capable of dominating benthic invertebrate communities Karatayev et al. 2003). The Asian clam usually occurs in high densities (thousands per square meter) (Gottfried and Osborne 1982, McMahon 1983, Stites et al. 1995) and accumulation of dead shells in large beds exemplifies its rapid life cycle (see Hackley et al. 2008 for images). Asian clam beds increase the nutrient load in the water column through excretion of organic wastes (elevated levels of nitrogen and phosphorus) and by re-suspending sediments, resulting in decreased water clarity from algal growth in nearshore areas (Chandra and Wittmann unpublished data). In addition to concerns about the direct impacts of Asian clams to the Lake Tahoe ecosystem, researchers are concerned that their presence may facilitate a dreissenid mussel invasion by increasing localized calcium concentrations in clam beds (Hackley et al. 2008). Research is underway in Lake Tahoe to test this hypothesis (Chandra and Wittmann unpublished data and see Appendix F).

Known occurrences of Asian clams in or near the Region include Lake Tahoe, Pyramid Lake, and the Lower Truckee River. Asian clams were observed during a 2002 survey of Lake Tahoe's south shore, revealing a small population that could have been present since the late 1990s (survey by Sudeep Chandra, UNR). During a 2008 survey of Lake Tahoe's south shore, beds were found in 4 to 40 m of water with densities ranging from zero to < 100 individuals m^2 up while others had >2000 individuals per m^2 (Wittmann et al. 2008) (Figure 6). Additional surveys for Asian clams are anticipated using an autonomous underwater vehicle (AUV) called the "Gavia" (http://gavia.is/) which will be used to take high resolution photography of the lake bottom to look for surficial clam shells as an indicator of live Asian clam presence. In areas where clam shells are sensed, ground truthing via benthic grab sampling and/or SCUBA or snorkel diving will be used. The AUV will also be able to sense chlorophyll levels via an externally attached, continuously sampling fluorometer.

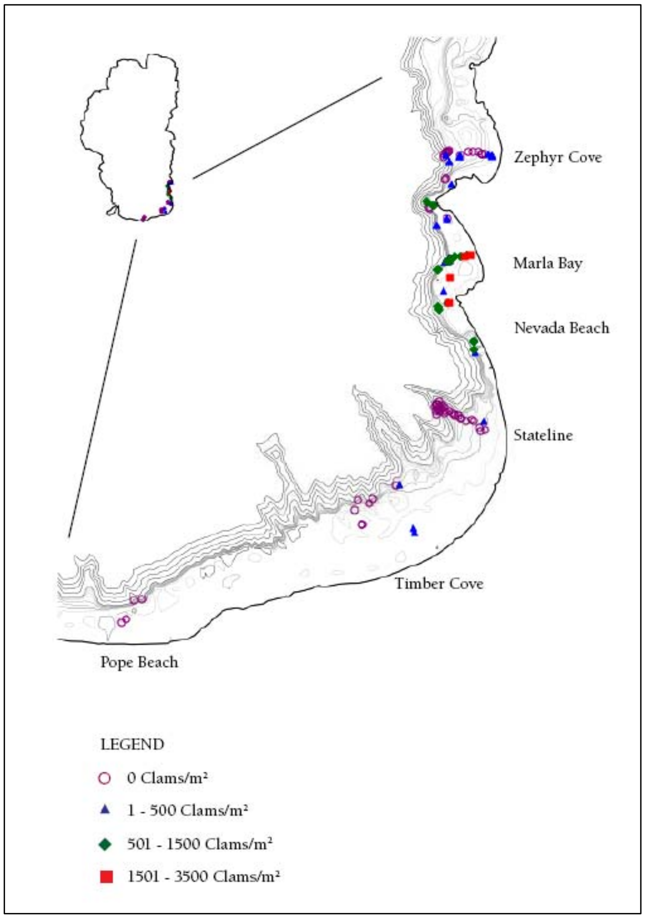

Figure 6. Asian clams densities from discrete locations in Lake Tahoe July – October 2008 (Wittmann et al. 2008)

Quagga and zebra mussels (dreissenid mussels) are two of the biggest threats to North America's freshwater ecosystems, and their presence often results in irrecoverable ecological damage with fiscal impacts of over $1 billion annually for control efforts in the U.S. (Pimentel et al. 2001). They grow in dense populations that encrust pipes, impede water movement, and colonize on other organisms (e.g., turtles, native mussels, crayfish, and aquatic plants) and structures (e.g., piers, docks, pilings, rope, and anchors). Dreissenid mussels are filter-feeders, commonly found in high flow areas such as pipes, intake structures, and pumps which can substantially reduce their flow efficiency, forcing expensive maintenance of pipes and other water conveyance structures. Dreissenid mussels are essentially impossible to eradicate once they become established.

Dreissenid mussels can filter about 1 L of water per day, primarily consuming phytoplankton but also other suspended material including bacteria, silt, and microzooplankton (USGS 2008). This results in transfer of substantial portions of the phytoplankton biomass from overlying surface water into the benthos, thereby increasing water clarity (Edwards et al. 2005). This can result in increased, and possibly toxic, blue-green algae blooms, which in turn increase odor problems. Increased water clarity can also allow for more light for the growth of submersed aquatic plants.

Colonization is common to areas where suspended organics or re-suspension from wave action occurs (e.g., shoreline areas) (Tuchman et al. 2004). These natural disturbances of nutrient rich sediments or aggregation of phytoplankton in higher densities at the shoreline support higher densities of dreissenid mussels. Ultra-oligotrophic waterbodies with non-point source nutrient runoff entering from shoreline development may also support increased mussel populations, resulting in locally-dense phytoplankton growth as nutrients are expelled directly from invasive bivalve excrement (Higgins et al. 2008).

No known populations of dreissenid mussels were known west of the 100th Meridian until January 2007 when quagga mussels were found in Lake Mead, Nevada. Since then, zebra mussels have been found in San Justo Reservoir, San Benito County, California and quagga mussels are present in waters in southern California, Nevada, and Arizona (Figure 7). More specifically, quagga mussels are present in the Lower Colorado River lakes (Lake Mohave AZ/NV; Lake Havasu, CA/AZ; Copper Basin Reservoir, CA). Quagga mussels were also found at the Nevada State Fish Hatchery (Lake Mead) and the Willow Beach National Fish Hatchery (Lake Mohave, AZ). The Nevada State Fish Hatchery has been decontaminated and NDOW is pursing an alternative water delivery system with the Southern Nevada Water Authority and modifying the water delivery system to provide treated water (quagga mussel free) to the facility. Most recently, dreissenid larvae were found in the Big Thompson Water Project which serves nearly 800,000 water users in northern Colorado. Within the Big Thompson Water Project, both quagga and zebra mussel larvae are currently in Grand Lake while only quagga mussel were found in Lake Granby and Shadow Mountain, Pueblo, and Willow Creek Reservoirs.

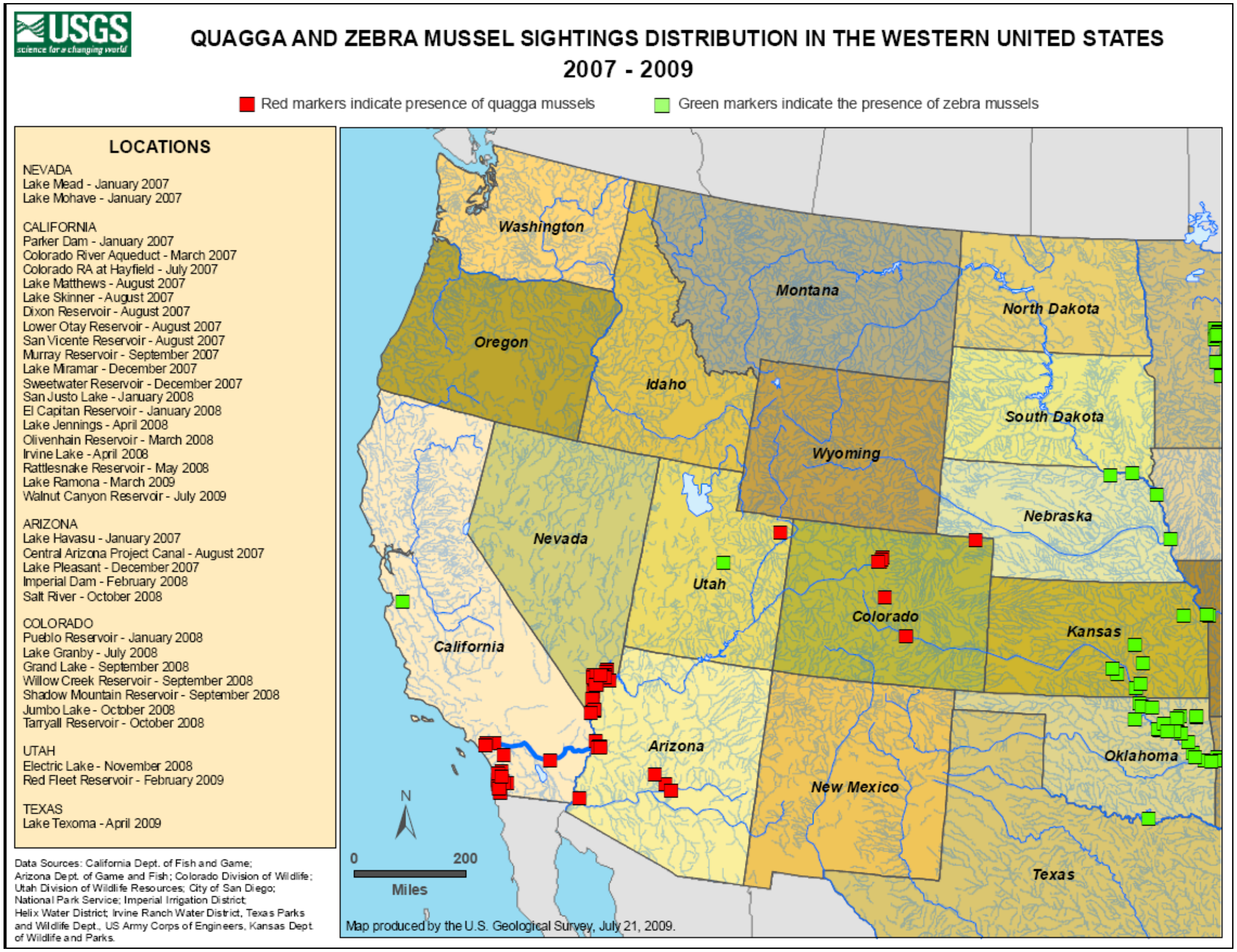

Figure 7. Distribution of quagga and zebra mussels in the western U.S. (http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/maps/southwest_quagga.pdf. Accessed July 21, 2009)

Quagga mussels colonize in higher abundance at greater depths (130 m) and colder water than zebra mussels (110 m) suggesting the quagga mussel is better adapted to cold-water than the zebra mussel (Mills et al. 1996). This observation highlights an interrelationship between water depth and level of disturbance where deeper water habitat tends to have largely undisturbed substrate composed of silty-sand, while shallower habitat is frequently affected by wave action (Mills et al. 1996). These differences have resulted in the spatial partitioning of the two species (Cohen 2007) along multiple environmental gradients, underscoring the importance for considering these relationships at all life stages.

Optimal conditions represented by the convergences of multiple environmental gradients determine the success of mussels and distribution in some systems. Based on a maximum colonization depth of 130 m potential quagga and zebra mussel habitat in Lake Tahoe is shown in Figure 8.

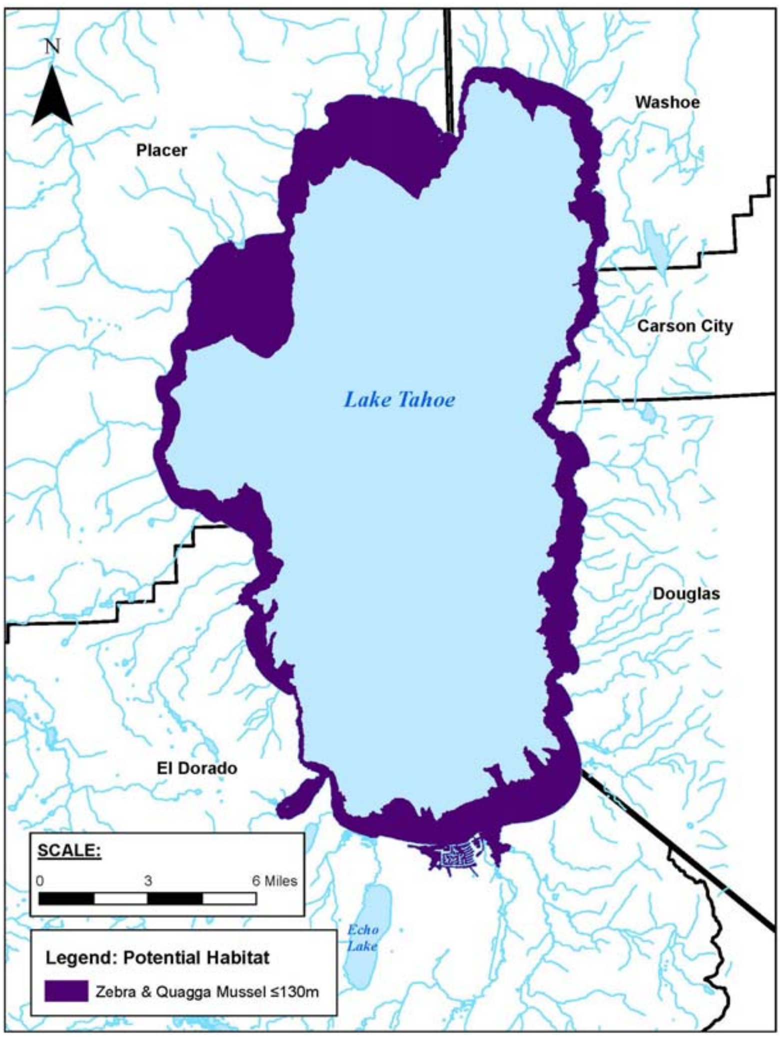

Figure 8. Potential quagga and zebra mussel habitat in Lake Tahoe, assuming survival depth ≤130 meters

Control/Eradication Methods for Other Species

Asian clams

In general, limited success has been achieved in controlling Asian clams. Chemical control of Asian clams is difficult and involves the use of chlorine or bromine to control juveniles. In Lake Tahoe, research is currently underway to physically manage Asian clams. A four-phase program has begun that involves 1) field testing of removal options, 2) evaluation of strategies, 3) implementation, and 4) long-term monitoring (Wittmann et al. 2009). The first phase involves evaluating the effectiveness 1) diver-operated suction, 2) the installation of benthic/bottom barriers, and 3) a combination of the two.

Dreissenid mussels

There are no widely accepted physical methods to substantially control or eradicate invasive invertebrates. Physical removal of dreissenid mussels from structures such as intake screen, trash grates, and cooling units may be accomplished by using pressure washing with water or dewatering structures and allowing them to dry (USACE 2009). Such physical methods, however, are only practical where water levels can be manipulated such as irrigation canals or hydropower facilities with redundant infrastructure to allow off-line cleaning. Methods of controlling dreissenid mussels from pipes include: physical pigging, manual cleaning, exposure to temperature that exceed thermal optima, or desiccation of viable life stages.

Physical pigging involves use of a tool (physical inspection gage; PIG) that is propelled through a pipeline and scrubs the interior with abrasive brushes removing attached mussels. This method of cleaning is a corrective measure and not a preventive measure. Manual cleaning can include use of pressure washers or abrasive brushes to remove the invading mussels. Manual cleaning is useful when the mussels are visible such as on the outside of boat hulls, docks, and natural surfaces that may be immersed in affected waterways and subsequently removed or exposed for a period of time. Exposure of dreissenid mussels to heated water over 38 ^{o}C is also effective in eradicating the adult life stage. Heated water is introduced into piping and exposes the invading mussels for a period of time. Return of the heated water to a lake is blended with lake water to reduce temperatures and lessen thermal impacts to receiving water biota. This is a non-chemical method for control the mussels and can be used on a periodic basis for maintenance of water conveyance structures and pumping equipment. Enclosed areas colonized by invasive mussels can be exposed to radiation by microwaves that heat surrounding water resulting in the same effect from exposure to pre-heated water.

A microbial pesticide (*Pseudomonas fluorescens* strain CL145A [Pf-CL145A]) is being investigated to control dreissenid mussels (Molloy 2002). The bacteria resemble food normally filtered by the mussel; however, ingestion of either live or dead cells does not stimulate valves to shut, destroying the mussel’s digestive system. Exposure of veliger or adult stages of dreissenid mussels to the biotoxin found in the bacteria results in 70 to 100% mortality. Limitations for use of this biological control method include achieving effective concentrations of bacteria in open water. Use in enclosed piping is less complicated as it provides a controlled environment for application. Non-target tests on *Daphnia magna* (a microscopic crustacean) indicate non-lethal effects from the bacterium. Efforts are currently underway to improve bacterium formulation for commercial products sales. In March 2009, a private company requested registration for a new active ingredient from the EPA for this microbial pesticide. The product is anticipated for commercial availability as soon as early 2010.

To prevent bio-fouling (undesirable accumulation) of organisms such as dreissenid mussels from attaching to aquatic structures, antifouling building materials and repellents are available. Antifouling building materials include: copper, galvanized iron, aluminum, acrylic, Teflon, vinyl, pressure-treated wood, black steel, pine, polypropylene, asbestos, stainless steel, and polyvinyl chloride (PVC) (Kilgour and Mackie 1993). Antifouling products that can be applied to surfaces include, coatings containing cuprous oxide that repel zebra and quagga mussels, foul-release coatings that minimizes byssal thread attachment, and thermal spray coatings that work by slowly releasing metals ions (Boelman et al. 1996). In the Tahoe Region, the use of antifouling coatings are restricted according to the Water Quality Management Plan for the Lake Tahoe Basin (208 Plan) and the Basin Plan, both summarized in Appendix A.

Several methods for chemical control of dreissenid mussels have been used, including use of chlorine, potassium permanganate, bromine, ozone, and molluscicides (Shaw 2004; Maguire and Sykes 2004). These treatments, however, are normally introduced to intake pipes and colonization locations for zebra and quagga mussels. Otherwise, obtaining effective concentrations in open water proves to be unachievable without harming other biota on a localized basis. The only known zebra mussel eradication to date occurred in Millbrook Quarry in Virginia. The small (5 ha) quarry was widely used for recreational diving which may have been the zebra mussel vector. Eradication was achieved using potassium chloride solution which is currently an unacceptable method in the Tahoe Region. No successful eradication of quagga mussels has been documented in North America (http://www.100thmeridian.org/).

New Zealand mudsnails

Currently, there is not widely accepted method to control New Zealand mudsnails. Research on a trematode parasite, *Microphallus* sp. as biocontrol agent for New Zealand mudsnails is underway (Fromme and Dybdhal 2006); however, no experimental methods will be considered for immediate implementation in this Plan.

The *National Management and Control Plan for the New Zealand Mudsnail* provides valuable information on vectors, pathways, and decontamination procedures that includes the following for waders and other equipment (NZMMCPWG 2007):

- Cleaning all mud and debris from boots, waders and gear with a stiff brush
- Putting fishing gear in a freezer for 6-8 hours

- Putting fishing gear in water maintained at 120°F for a at least 5 minutes will eliminate New Zealand mudsnails (Dwyer et al. 2003; Medhurst 2003; Robyn Draheim, Portland State University, March 19, 2009) (mudsnails can survive at 110°F)
- Dry fishing gear at 84-86°F for at least 24 hours or at 104°F for at least two hours (gear may be brushed with a stiff bristled brush prior to drying).

Bullfrogs

To control adult bullfrogs, a variety of methods may be deployed, including shooting, spears/gigs, bow and arrow, clubs, nets, traps, angling, and by hand (GISD 2008). They tend to be extremely shy, but can be caught by use of a strong spotlight at night and collected by hand or alternatively can be shot. Collecting egg masses using a bilge pump can be an effective adjunct control method (Govindarajulu 2004). Targeting egg searches to areas where male bullfrogs are heard calling during the night may improve the probability of detecting egg masses (Govindarajulu 2004). Incomplete removal of eggs or larvae, however, can inadvertently increase the growth and survival of the remaining individuals and cause an increase in the population (Govindarajulu 2004). Bullfrogs can also be controlled by ringing the aquatic areas where they are established with reptile-proof fencing to catch neonates and placing traps in terrestrial areas to catch dispersing adults.

Direct removal of bullfrog is often very difficult and typically unsuccessful due to their high fecundity rate, high dispersal capability, opportunistic diet, and the complex habitats in which they are often associated. Habitat manipulation, in association with direct removal efforts, could prove more successful. Maret et al. (2006) used a method of draining and drying ponds to eliminate bullfrogs. Because bullfrogs overwinter as larvae and are dependant on permanent water for growth, this method has shown some success. Doubletree et al. (2003) used models to determine necessary draining intervals to reduce numbers. Their model suggests that direct removal of adults in combination with periodic drying (approximately every two years) could allow native amphibians the opportunity to reestablish. Although this could be successful, it is undetermined how periodic draining would impact other native species that also rely on a permanent water source.

3.4 Non-native Species Types

Similar to the CAISMP, species management types/categories were developed by the LTAISCC to facilitate the prioritization of management objectives (Table 5). This system will be used to categorize non-native species in the Region and those threatening introduction. Table 6 lists the estimated dates of species introduction (if present), known pathway of introduction, and applicable state and federal pest ratings (hereafter all species referred to by common name).

Table 5. Non-native Species Management Types

Species Management Type	Current Management Response
Type 1 Not yet detected in the Region	Prevention Monitoring Education
Type 2 Limited in extent with operational control* options	Monitoring Control/Eradication
Type 3 Established with operational control* options	Prevention Monitoring Control/Eradication Education Research
Type 4 Established but no operational control* options	Monitoring Research
Type 5 Unknown invasion potential	Prevention Research
Type 6 Legal introduction	Education Research

*Operational control refers to legal and permitted control and eradication methods, e.g., hand-removal of aquatic plants, diver-assisted suction for Asian clam removal.

Table 6. Non-native Species Presently In or Threatening the Lake Tahoe Region

Group	Common name	Scientific name	In Tahoe Region (since)	Pathway	Applicable Pest Rating
Type 1: Not yet detected in the Region					
Aquatic Plants	Brazilian egeria	*Egeria densa*	N	AT, RA	CDFA "C" NRS 503.597
	Fanwort	*Cabomba caroliniana*	U	AT	CDFA "Q" NRS 503.597
	Giant salvinia	*Salvinia molesta*	N	AT	CDFA "A" NDA "A" Federal NRS 503.597
	Hydrilla	*Hydrilla verticillata*	N	AT, RA	CDFA "A" NDA "A" Federal NRS 503.597
	Oxygen weed	*Lagarosiphon major*	N	AT	CDFA "Q" Federal
	Parrot feather	*Myriophyllum aquaticum*	U	AT	NRS 503.597
	S. American spongeplant	*Limnobium laevigatum*	N	AT, RA	CDFA "A" NRS 503.597
	Water chestnut	*Trapa natans*	N	AT	NRS 503.597
	Yellow flag iris	*Iris pseudacorus*	N	AT	NRS 503.597
	Yellow floating heart	*Nymphoides peltata*	N	AT	NRS 503.597

Table 6 cont.

Group	Common name	Scientific name	In Tahoe Region (since)	Pathway	Applicable Pest Rating
Fishes	Northern pike	*Esox lucius*	N	ISI	CDFG NRS 503.597 NAC 503.110
	Smallmouth bass	*Micropterus dolomieui*	U (attempted introduction in 1895)	ISI	NRS 503.597 NAC 503.060
	Mosquitofish	*Gambusia affinis*	U	RM	CDFG NRS 503.597
Other Species	New Zealand mudsnail	*Potamopyrgus antipodarum*	U	RA	CDFG NRS 503.597 NAC 503.110
	Quagga mussel	*Dreissena bugensis*	N	RA	CDFG NRS 503.597 NAC 503.110
	Spiny waterflea	*Bythotrephes longimanus*	N	RA	NRS 503.597
	Zebra mussel	*Dreissena polymorpha*	N	RA	CDFG US NRS 503.597 NAC 503.110
Type 2: Limited in extent with operational control options					
Aquatic Plants	Curlyleaf pondweed	*Potamogeton crispus*	Y[1] (2003)	RA	NRS 503.597
Fishes*	-	-	-	-	-
Other Species	Bullfrog	*Rana catesbeiana*	Y[1] (late 1940s)	AT, RM	NRS 503.597

Table 6 cont.

Group	Common name	Scientific name	In Tahoe Region (since)	Pathway	Applicable Pest Rating
Type 3: Established with operational control options					
Aquatic Plants	Eurasian watermilfoil	*Myriophyllum spicatum*	Y[1] (early-1990s)	RA	CDFA "A" NDA "A" NRS 503.597
Fishes	Black crappie	*Pomoxis nigromaculatus*	Y[1] (late 1980s)	ISI	NRS 503.597 NAC 503.060
	Bluegill	*Lepomis macrochirus*	Y[1] (late 1980s)	ISI	NRS 503.597 NAC 503.060
	Brown bullhead	*Ameiurus nebulosus*	Y[1] (early 1960s)	ISI	NRS 503.597 NAC 503.060
	Common carp	*Cyprinus carpio*	Y[1] (late 1900s)	ISI	CDFG NRS 503.597
	Fathead minnow	*Pimephales promelas*	U	RA	CDFG NRS 503.597
	Goldfish	*Carassius auratus auratus*	Y[1] (late 1980s)	ISI	NRS 503.597
	Green sunfish	*Lepomis cyanellus*	Y[1] (late 1980s)	ISI	NRS 503.597
	Largemouth bass	*Micropterus salmoides*	Y[1] (late 1980s)	ISI	NRS 503.597 NAC 503.060
	White crappie	*Pomoxis annularis*	N	ISI	NRS 503.597 NAC 503.060
Other Species	Asian clam	*Corbicula fluminea*	Y[1] (early 2000s)	RA	NRS 503.597

Table 6 cont.

Group	Common name	Scientific name	In Tahoe Region (since)	Pathway	Applicable Pest Rating
Type 4: Established but no operational control options					
Aquatic Plants	Rock snot	*Didymosphenia geminate*	Y	RA	NRS 503.597
Fishes	-	-	-	-	-
Other Species	Gill maggot	*Salmincola californiensis*	Y[1] (2006)	RA, RM	NRS 503.597
	Signal crayfish	*Pacifastacus leniusculus*	Y[2] (1895 & 1909)	ISI	NRS 503.597
Type 5: Unknown invasion potential					
Aquatic Plants	Water hyacinth	*Eichorrnia crassipes*	N	AT	CDFA "C" NRS 503.597
	Water lettuce	*Pistia stratiotes*	N	AT	CDFA "B" NRS 503.597
Fishes	-	-	-	-	-
Other Species	-	-	-	-	-
Type 6: Legal introduction					
Aquatic Plants	-	-	-	-	-
Fishes*	Brook trout	*Salvelinus fontinalis*	Y[2] (1870s)	MF	NAC 503.060 NRS 503.597
	Brown trout	*Salmo trutta*	Y[2] (1896)	MF	NAC 503.060 NRS 503.597
	Golden shiner	*Notemigonus crysoleucus*	Y[1] (early 1960s)	RA	NRS 503.597

Table 6 cont.

Group	Common name	Scientific name	In Tahoe Region (since)	Pathway	Applicable Pest Rating
Fishes cont.	Golden trout	*Salmo aquabonita*	N (but introduced in 1918)	MF	NRS 503.597
	Kokanee salmon	*Oncorhynchus nerka*	Y[2] (1949)	MF	NRS 503.597
	Lake trout/Mackinaw	*Salvelinus namaycush*	Y[2] (1888)	MF	NAC 503.060 NRS 503.597
	Rainbow trout	*Oncorhynchus mykiss*	Y (1880s)	MF	NAC 503.060 NRS 503.597
Other Species	Mysid shrimp	*Mysis relicta*	Y[2] (1963-65)	ISI	NRS 503.597

Table 6 notes:

Sources of information for Table 6: LTAISCC, LTAISWG, applicable state or federal regulations, Vander Zanden et al. 2003; Anderson 2007; Kamerath 2008; Hackley et al. 2008; USGS 2008; NDOW; USFS-LTBMU

*Desirable non-native, coldwater game fish are actively managed in the Region through stocking programs or possession limits by NDOW (NAC 503.060) and CDFG. As of November 21, 2008, however, CDFG stocking programs are substantially reduced pending completion of an Environmental Impact Report (EIR) which is expected to be completed January 1, 2010. Waterbodies in the Region with halted stocking programs can be found at: http://www.dfg.ca.gov/news/stocking/.

Y = Yes; [1] = Detected; [2] = Intentionally Introduced

N = No

U = Unknown; no known surveys have been conduced and no documentation of the presence of this species has been located.

This does not constitute verification of presence or absence of this species

RM = Resource Management activities (i.e., fish stocking, vector control)

ISI = Intentionally Stocked Invasive

MF = Managed Fishery

RA = Recreational Activities

AT = Aquarium Trade

NDA = Nevada Department of Agriculture

“A” Weeds not found or limited in distribution throughout the state; actively excluded from the state and actively eradicated wherever found; actively eradicated from nursery stock dealer premises; control required by the state in all infestations

“B” Weeds established in scattered populations in some counties of the state; actively excluded where possible, actively eradicated from nursery stock dealer premises; control required by the state in areas where populations are not well established or previously unknown to occur

“C” Weeds currently established and generally widespread in many counties of the state; actively eradicated from nursery stock dealer premises; abatement at the discretion of the state quarantine officer

NAC = Nevada Administrative Code

NRS = Nevada Revised Statue

CDFA = California Department of Food and Agriculture Pest Ratings (Policy Letter #89-2; April 28, 1989)

“A” An organism of known economic importance subject to state (or commissioner when acting as a state agent) enforced action involving: eradication, quarantine, containment, rejection, or other holding action

“B” An organism of known economic importance subject to: eradication, containment, control or other holding action at the discretion of the individual county agricultural commissioner.

“C” An organism subject to no state enforced action outside of nurseries except to retard spread. At the discretion of the county agricultural commissioner.

“Q” An organism requiring a temporary “A” action pending determination of a permanent rating. It is suspected to be of economic importance, but its status is uncertain because of incomplete identification or inadequate information.

“D” Organisms determined to be of little or no economic importance

CDFG = California Department of Fish and Game, Restricted Species, California Code of Regulations Title 14 §671.5

US = U.S. Fish and Wildlife Service, Lacy Act CFR 16.11-16.15

4 Plan Development

The Plan was prepared by Tetra Tech, Inc. staff and greatly facilitated by numerous stakeholders, researchers, and agency staff, particularly the LTAISCC and the LTAISWG (Appendix A and Appendix D).

The Plan is based on the ANSTF's *Guidance for State and Interstate Aquatic Nuisance Species Management Plans*. The Implementation Table (Table 8) was developed by the LTAISCC and Tetra Tech, Inc. staff in a day long meeting on September 17, 2008 as a cooperative team effort. The timeline for plan development, stakeholder meetings, comments, and ANSTF presentation and approval is summarized in Figure 9.

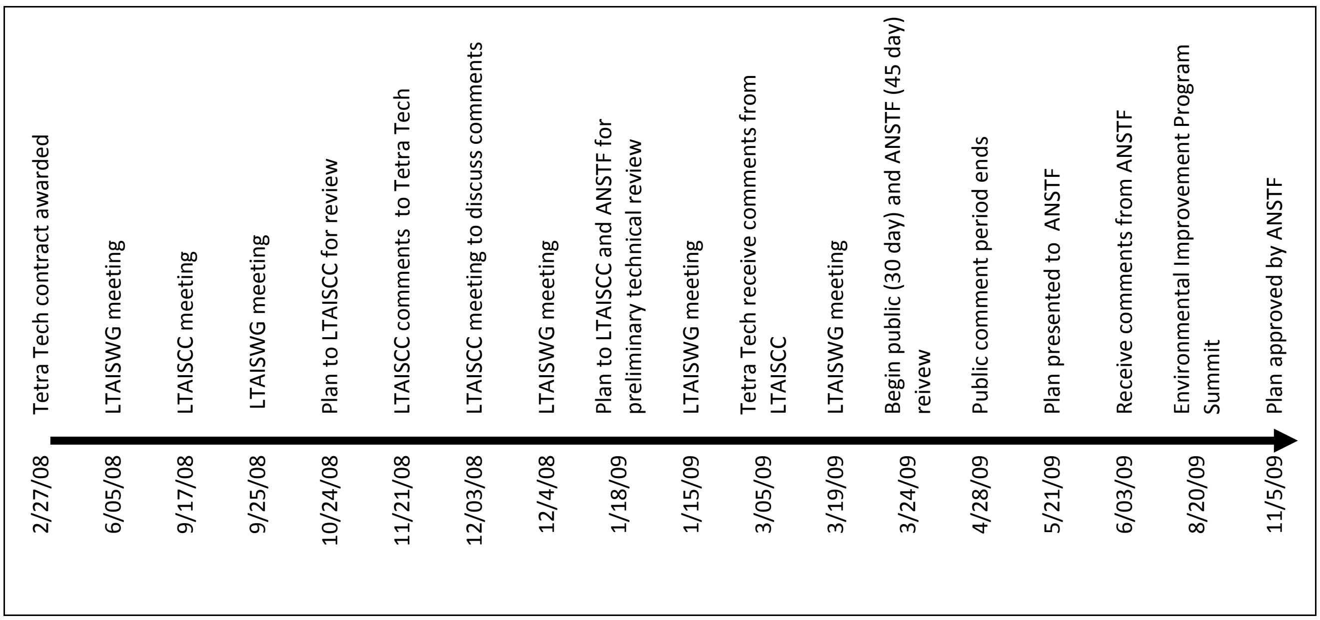

Figure 9. Lake Tahoe AIS Management Plan Development Timeline

Drafts of the Plan were submitted by Tetra Tech, Inc. to the LTAISCC on October 24, 2008 and on January 18, 2009 a second draft was submitted to the LTAISCC, the LTAISWG and to Ronald Smith, AIS Coordinator for USFWS - Region 8, for a cursory review. Comments were received from the CADPR, CDFG, California State Lands Commission (CSLC), LRWQCB, NDOW, NDSL, TRCD, TRPA, Tahoe Science Consortium (TSC), UCD – Tahoe Environmental Research Center (UCD – TERC), UNR, USDA-ARS, and the USFS – LTBMU. To facilitate Tetra Tech, Inc. in their response to comments, a LTAISCC review sub-committee was formed (identified in Appendix D) and met by conference call, email, and in person as needed. On March 24, 2009, a third draft of the Plan was posted to the TRPA website for a 30-day public comment period and simultaneously submitted to the ANSTF for a preliminary 45-day review. During the public comment period, additional comments were received by CADPR but no comments were received from the general public.

All comments and responses are presented in Appendix G and some common themes are summarized below:

- Does the geographic scope of the Plan cover the Lake Tahoe Basin or Lake Tahoe Region (as defined by TRPA Compact)?
- Clearly separate desirable non-native game fish from unwanted and invasive fish species. (e.g., largemouth bass)
- Define "invasive" species and distinguish invasive from non-native desirable or managed species, e.g. coldwater game fish
- Identify species *invasive* to the Lake Tahoe Region, their estimated dates of introduction, and assumed pathway for introduction, i.e., develop the ranking systems
- Rank or categorize non-native species to improve understanding of AIS issues
- Requested additional non-native species be added to Table 6, including bullfrog, spiny Waterflea, and smallmouth bass
- Explain why the life histories, invasive life strategies, and environmental requirements are identified for some species list in Table 6 but not all.
- Suggest adding information on collaboration/coordination with the WRP and the Quagga-Zebra Mussel Action Plan for Western U.S. Waters (known as "QZAP")

5 Management Plan Goals and Objectives

The goals of the Lake Tahoe AIS Management Plan are to:

I. Prevent new introductions of AIS to the Region

II. Limit the spread of existing AIS populations in the Region, by employing strategies that minimize threats to native species, and extirpate existing AIS populations when possible

III. Abate harmful ecological, economic, social and public health impacts resulting from AIS

These goals will be accomplished by strengthening existing education and prevention measures including but not limited to staffed boat inspections at launches, billboards, signage, television commercials and, when available, boat sniffing dogs. These education and prevention measures must be adaptable and proactive to meet emerging issues. In addition, adoption of early detection monitoring protocols is paramount to this effort and the ability to rapidly respond is also needed. Control and eradication efforts must also be immediately ramped up to prevent in-lake spread of existing populations. The LTAISCC identified seven objectives (Table 7) to meet the Plan's goals to limit AIS introductions, spread, and reduce their impacts.

Table 7. Lake Tahoe Region AIS Management Plan Objectives

Objective	Title	Brief Description
A	Management Plan Implementation and Updates	Determine implementing organization(s); determine review and revision protocols
B	Coordination and Collaboration	Continue to improve coordination efforts between and among various stakeholder groups
C	Prevention	Prevent the spread of existing AIS and the introduction of new AIS to the Tahoe Region
D	Early Detection, Rapid Response and Monitoring	Develop and maintain programs that: • Ensure the early detection of new AIS introductions • Monitor existing AIS populations • Establish and manage systems to rapidly respond to new AIS introductions
E	Long Term Control and Management	Establish and maintain funding sources to support activities that minimize impacts of AIS to native species and protect water quality and environmental health
F	Research and Information Transfer	Increase research on a) the baseline biology of AIS currently in or threatening introduction to Lake Tahoe, b) survivability thresholds for potential AIS, c) innovative detection technologies, d) alternative control strategies
G	Laws and Regulations	Coordinate existing regional, state, and federal laws and regulations related to AIS and provide guidance and education that direct content and needed policy

6 Current/Short- and Long-term Strategies and Actions

Prior to the development of this Plan, resource managers, researchers, and many community members recognized the need for organized AIS prevention, education, control, and research. Partnerships such as the LTAISWG and the LTAISCC have not only facilitated development of this Plan, but their early strategies and actions demonstrate the momentum to protect waterbodies in the Lake Tahoe Region from further degradation from AIS.

This section identifies current/short-term (i.e., through fiscal year 2009) and long-term (i.e., fiscal year 2010 to 2015) strategies and actions. Additionally, the Implementation Table (Table 8) identifies the lead and cooperating entities, current funding, and where applicable, anticipated funding needed to implement actions over the five year period from 2010 to 2015.

6.1 Objective A: Management Plan Implementation and Updates

As an interstate management plan, strong oversight is necessary to ensure Plan objectives and action items continue to meet the goals of the Plan within the existing regulatory framework of both states and the Region. This requires identifying lead organizations to support Plan development, oversight, implementation and adaptive review.

Strategy A1: Oversight and Implementation

The following action items describe the process of Plan development and implementation and identifies the lead fiscal agent to facilitate financial transfer of funds, as needed, to support action items.

Actions

A1a. Development of the Lake Tahoe Region AIS Management Plan

Development of the Plan was directed by the USACE and CTC in cooperation with the LTAISCC. The Plan was developed according to the *ANSTF Guidelines for Preparing State and Interstate Aquatic Nuisance Species Management Plans*. The Plan was reviewed by the LTAISCC, members of the LTAISWG, a cursory review by CDFG, and three independent reviewers before the 45-day preliminary review by the ANSTF and simultaneous public comment period.

A1b. Lead Organization for Plan Oversight

Numerous regional, state, federal, and non-governmental organizations are involved in protecting and advocating for the environmental, recreational, and economic stability of Lake Tahoe. Implementation of the Plan will require committed oversight by an organization capable of regulation across the boundaries between the California and Nevada, federal and multiple local jurisdictions. The Tahoe Regional Planning Agency (TRPA) was created by California and Nevada as well as the U.S. Congress to have this regulatory power. It follows that TRPA is the one agency most suited for the oversight role.

A1c. Implementation of the Lake Tahoe Region AIS Management Plan

Implementation of the Plan will largely be conducted by the LTAISCC and LTAISWG. Both groups have representatives from regional, state, and federal agencies and non-profit groups from the Lake Tahoe Region.

A1d. Funding for Aquatic Nuisance Species (ANS) Coordinator

SNPLMA Round 8 and 9 funds currently support the USFWS ANS Coordinator for the Tahoe Region. Continued funding for this position is critical to for coordinating AIS prevention, management, and research efforts in the Region in collaboration with state (e.g., CDFG, NDOW, CDFA) and regional agencies (e.g., TRPA, WRP) and guidance at the national level (e.g., ANSTF).

A1e. Fiscal Agent for Plan

The TRPA has the ability to act as a fiscal agency for the implementation of the Plan. The TRPA cooperatively leads and successfully manages the Tahoe EIP, and has demonstrated the ability to be nimble when acting as a pass-through agency for funding proposes. For example, TRPA can pass funds from a State of California agency to a State of Nevada agency.

Strategy A2: Review Process

Timely review of the Plan is necessary to ensure strategies and specific action items continue to support the Plan's goals. New AIS threats and pathways of introduction should be evaluated for inclusion in updated Plan versions. Additionally, funding sources and levels should be considered to keep the Plan timely and ensure stakeholders have the support to implement the action items.

Actions

A2a. LTAISCC Review Sub-committee

The LTAISCC was critical in development of the actions described in the Implementation Table, including identifying lead and supporting organizations. The LTAISCC is poised to evaluate Plan effectiveness and identify gaps that limit the Plan's acceptance and implementation by stakeholders from both Nevada and California. A sub-committee will be formed to address these issues. Members of the sub-committee will be:

- Familiar with AIS issues, regulations, and laws at the regional, state, and federal levels
- Familiar with other regional and state AIS plans
- Capable of recommending strategies to improve the effectiveness of the Plan
- Lead data assessment relative to progress on control and prevention and recommend adaptive management changes

A2b. LTAISCC Sub-committee Review

A year after Plan acceptance by the ANSTF, and annually thereafter, the Plan will be reviewed by the LTAISCC review sub-committee described above and presented to the LTAISCC. Key elements to address during this review are included in Section 8.

A2c. Plan Revision

A minimum of five years after Plan acceptance by the ANSTF, or if a Plan revision is deemed required based on A2d, the Review sub-committee shall follow revision procedures identified by the ANSTF. Current procedures may be found at: http://anstaskforce.gov.

A2d. Considerations for Plan Revision

During plan revision, first determine whether minor technical revisions, major technical revisions, or a complete plan overhaul is required (see *Developing and Revising State and Interstate Aquatic Nuisance Species (ANS) Management Plans* for further information on these levels and relevant required ANSTF approval).

Strategy A3: Funding

Sources of funds that support current AIS prevention, management and research activities in the Region come from a variety of sources ranging from federal and state programs to private donations (details in Appendix E). Federal funds currently authorized under Section 1204(b) of the NANPCA are limited to $4 million, split among other state AIS management plans. An additional $1.075 million is available from the USFWS for ANTSF-approved plans, however this is similarly split between state and interstate AIS plans. In 2009, the 31 approved plans received only $34,677. Increasing funding for state and interstate management plans to $30 million has been identified as a high priority in the Quagga-Zebra Mussel Action Plan for Western U.S. Waters (QZAP) (WRP 2009).

Actions

A3a. Establish LTAISCC Financial Sub-committee

A sub-committee of the LTAISCC shall be formed to:

- Interface with the LTAISWG to prioritize prevention, management, capital investments, and research needs
- Interface with the LTAISWG to determine funding sources for high priority needs
- Request NANPCA Section 1204 funds from the ANSTF for specific action items (as identified in the ANSTF-accepted Plan)
- Request funds for specific action items from non-Section 1204 funding sources

6.2 Objective B: Coordination & Collaboration

Numerous prevention, monitoring, education, and research projects are currently underway in the Region. This work is conducted by a variety of agencies, academics, and NGO's and in many cases the work is in collaboration with the LTAISWG. Actions included in this objective are aimed at improving and expanding existing AIS activities in the Region. Anticipated outcomes from these efforts will greatly improve funding partnerships, reduce or even eliminate redundant efforts, alert resource managers to emerging AIS problems, and facilitate bi-state collaboration.

Strategy B1: Regional, Bi-state, National and International

The following action items describe how regional, bi-state, national and international coordination and collaboration efforts may be improved to prevent and control AIS in the Region.

Actions

B1a. Nevada AIS Management Plan

Western states with ANSTF-approved AIS management plans include: California, Washington, Idaho, Montana, Oregon, and Utah (conditional). The CDFG completed the CAISMP in January 2008. Even though Nevada is currently without an ANSTF-approved AIS plan, NDOW currently has draft versions of the "Quagga Mussel Monitoring Program" as well as "Prevention and Disinfection Guidelines". The Arizona Invasive Species Advisory Council recently released *Arizona Invasive Species Management Plan 2008* in which the impacts and prevention of AIS are included. The Arizona Game and Fish Department is currently working to finalize an aquatic-specific invasive species plan. The absence an AIS plan from Nevada, an important recreational state where quagga mussels are found in Lakes Mead and Mojave, leaves the Tahoe Region particularly vulnerable to AIS introduction. The development and implementation of a Nevada AIS Management Plan is needed to:

- Prevent further spread of AIS between Nevada waterbodies and, by extension, prevent the introduction of devastating AIS to the Lake Tahoe Region
- Reinforce consistent AIS prevention messages
- Potentially increase enforcement, quarantine, and inspection authorization in Nevada
- Create and maintain a regional AIS buffer around the Tahoe Region to keep AIS out of surrounding watersheds

B1b. LTAISCC and LTAISWG

Continue monthly meetings of the LTAISCC and LTAISWG to identify and prioritize research needs, determine matching funds and share results between numerous agencies and organizations in the Tahoe Region.

B1c. Annual LTAISWG Reports

Continue synthesis and distribution of the annual LTAISWG summary of accomplishments and goals.

B1d. Foster Shorezone Partnerships

Foster partnership development among shore zone property owner/managers (e.g., Washoe Tribe, yacht club owners) to increase involvement in LTAISWG.

B1e. Link LTAISCC to State, National, and International AIS Groups

New AIS and introduction pathways are rapidly emerging due to increased internet trade, world-wide travel, and climate change. Similarly, innovative prevention and control methods are also increasing. To stay abreast of these emerging challenges and resources, stakeholders in the Region must be engaged with other state (particularly neighboring western states), national and even international AIS managers and researchers. Examples of organizations include (links provided in Appendix D):

- Aquatic Nuisance Species Task Force (ANSTF)
- California Department of Fish and Game (CDFG)
- California AIS Advisory Council (CAISAC)
- Invasive Species Specialist Group (ISSG)
- Sea Grant
- The 100th Meridian Initiative
- United States Geological Survey (USGS)
- Western Regional Panel (WRP)

6.3 OBJECTIVE C: PREVENTION

Preventing the introduction of AIS to the Lake Tahoe Region (inter-region) and further spread of existing AIS within the Lake Tahoe Region (intra-region) requires adequate inspection and decontamination procedures coupled with effective and consistent education and outreach. Additionally, targeting prevention efforts to high risk introductory pathways will maximize limited resources.

Strategy C1: Inspection and Decontamination

The objective of decontamination is to completely eliminate all viable AIS life stages to prevent their introduction into waters of the Lake Tahoe Region. Such extreme action is needed as anything less will not be effective in preventing the introduction and further spread of AIS. Decontamination efforts should be extended to a variety of equipment, including watercraft, personalized watercraft, waders, construction equipment, et cetera from *all* AIS (i.e., snails, plants, mussels, and other less conspicuous organisms).

Actions

C1a. Vessel Inspection Plan (VIP)

Implement the VIP as according to TRPA Chapter 79.3 of the Code of Ordinances which provides for vessel decontamination and the closure of launch facilities when inspectors are not present. TRCD and TRPA staff have been certified by the 100th Meridian Initiative to provide inspection and decontamination trainings to contractors, launch facility staff and Washoe Tribe inspectors. The types of watercraft that are subject to inspection and possible decontamination include trailered boats and small watercraft such as canoes and kayaks entering Lake Tahoe. The most current version of the VIP can be found in Appendix B.

C1b. Fee-based System to Support VIP

Implement the TRPA Governing Board approved fee (effective June 1, 2009) to support the VIP adopted March of 2009. The fee will be assessed for each inspection of a motorized vessel. Vessels with an intact inspection seal that confirms that they last launched in Lake Tahoe are exempt from inspection and the fee. Reassess the fee on at least a yearly basis to determine if changes are needed, such as changes to the fee if other funds are found to offset costs.

C1c. Small Watercraft Screening

Implement the *Small Watercraft Screening Process for Aquatic Invasive Species* developed by the USFS-LTBMU (Appendix C). The purpose of this program is to reduce the likelihood of AIS introduction from non-motorized watercraft at campgrounds and other day-use facilities around Lake Tahoe.

C1d. Non-motorized Watercraft Inspection

Integrate inspection and decontamination protocols for all non-motorized watercraft, including the Small Watercraft Screening procedures outlined by the USFS-LTBMU (Appendix C). As a first stop in this effort, the LTAISWG recently formed a non-motorized boat inspection and education sub-committee.

C1e. Evaluate Decontamination Methods

Conduct spot checks to ensure proper watercraft decontamination protocols are followed.

C1f. Ensure Decontamination of a Range of Equipment

Ensure there is full decontamination of equipment related to recreation, natural resource management, research, and construction activities.

C1g. Ensure Decontamination of a Range of AIS

Ensure inspection and decontamination procedures address all life stages of targeted, and non-targeted AIS. That is, train inspectors to look for a range of organisms (e.g., spiny waterflea) and not just mussels and plants.

C1h. Develop Professional AIS Inspector Program

Collaborate with the 100th Meridian Initiative to develop a program to certify professional watercraft inspectors. Such a program would provide a mechanism to communicate with certified inspectors across the U.S., thereby providing consistent updates on emerging AIS challenges, innovative outreach techniques, and maintain consistent inspection protocols.

C1i. National and International Contacts

Maintain regional, national and international contacts to stay apprise of alternative and current decontamination methods by appointing a LTAISWG member for this role.

Strategy C2: Pathways/Vectors

The physical means or agent by which AIS are transported to a new environment and eventually establishes is an AIS pathway or vector. These dispersal mechanisms can be natural or human connections that allow movement of species or their reproductive propagules from place to place.

Actions

C2a. Boaters

Continue to educate boaters about the risk of transporting AIS; not only to the Region, but out of the Region. Ensure watercraft inspectors are adequately trained to identify a range of organisms harbored on trailered watercraft (C1f and C2g).

C2b. Anglers

Continue to educate anglers to wash fishing equipment prior to its use in Region waterways.

C2c. Natural Resource Management

Continue to ensure that resource managers are aware of the potential to transport AIS (e.g., New Zealand mudsnails on waders and other sampling equipment) and that adequate decontamination measures are taken.

C2d. Wildfire Suppression Activities

Ensure that AIS are not transported between waterbodies by equipment used for wildfire suppression activities by following, where possible, the USFS-LTBMU's *Resource Guidelines for Wildfire Suppression*.

C2e. Construction Activities

Ensure that AIS are not transported between waterbodies by equipment used for construction activities (e.g., culvert placement, dock and pier maintenance).

C2f. Fish Stocking

Continue to provide adequate decontamination of equipment used to transport hatchery-raised fish for stocking.

C2g. AIS Identification

Train field biologists and boat inspectors to properly identify a range of AIS (and their life stages) including but not limited to dreissenid mussels, Asian clams, Eurasian watermilfoil, curlyleaf pondweed, and other potential invaders such as the spiny water flea.

Strategy C3: Education

Education is key to any effective management program and numerous efforts are currently underway in the Region, including providing clear and consistent messages to various users, including boaters and anglers. Maintaining a dialogue with resource managers in other regions of the U.S. and internationally will allow for information sharing and increase message recognition (e.g., *Stop Aquatic Hitchhikers!*).

Actions

C3a. LTAISWG Education/Outreach Plan

Continue to develop the Education/Outreach Plan including participation from aquatic nurseries and landscaping companies.

C3b. Stop Aquatic Hitchhikers! Campaign

Continue to utilize the USFWS *Stop Aquatic Hitchhikers!* message to improve national recognition.

C3c. Habitattitude National Public Awareness Campaign

Assess the appropriateness of using the USFWS/ANSTF Habitattitude National Public Awareness Campaign in the Region.

C3d. Press Releases

Increase the use of press releases during high travel season to warn travelers of boat inspections and potential decontamination procedures, particularly if they are traveling from high risk waterbodies during peak travel seasons.

C3e. Advertising and Publications

Continue the use billboards, magazine, radio, and cable television advertisements to warn travelers of boat inspections and potential decontamination procedures, particularly during peak travel seasons. Also, incorporate the use of direct mailings to residents in the Lake Tahoe Region.

C3f. National and International

Continue to maintain and encourage national and international contacts to stay apprise of effective education methods, i.e., Sea Grant Program and *Stop Aquatic Hitchhikers!* campaign.

C3g. Aquascaping

Provide specific recommendations to vendors/suppliers and the general public for using suitable native plants and animals instead of non-native species in aquascaping projects.

C3h. AIS Hotlines

Continue to maintain regional (888-TAHO-ANS) and national (877-STOP-ANS) phone hotlines and to report sightings of AIS. Also continue to provide appropriate knowledgeable response.

6.4 Objective D: Monitoring, Detection, and Response

Following prevention, early detection, containment and control/eradication of new AIS introductions are the second most cost-effective measures to reduce the impacts from AIS. This is accomplished through rigorous monitoring followed by the ability to respond efficiently and aggressively. Response is facilitated by a collaborative effort between numerous agencies, NGO's, researchers, and other stakeholders.

Strategy D1: Potential AIS

Understanding the distribution and impacts of potential AIS (i.e., Species Management Types 1, 5) may be used as a benchmark for future management assessments and prioritization.

Actions

D1a. At-risk Waterbodies in Region

Identify waterbodies in the Region that could host specific AIS throughout all life stages. For example, if similar water quality conditions exist between Lake Tahoe and Fallen Leaf Lake, then efforts should be made to prevent the transport of aquatic weeds from Lake Tahoe to Fallen Leaf (note: a wash station is currently in operation at Fallen Leaf Lake).

D1b. Volunteer AIS Monitoring

Increase/recruit and train local volunteer monitors that routinely use Lake Tahoe and surrounding streams and lakes for recreation and aesthetic enjoyment. The likelihood that volunteers in close proximity to Lake Tahoe will routinely collect continuous information is greater based on ease of access and interest in promoting wise stewardship of area resources.

D1c. AIS-infested Waterbodies

Maintain a list of rivers and lakes outside of the Region with AIS. This list may be used to determine at-risk vessels so that inspectors can activate appropriate precautionary AIS prevention protocols. These records can be shared with inspectors in nearby watersheds and resource managers from AIS points-of-origin to coordinate an early-warning network for potential AIS transport.

D1d. At-risk In-lake Habitats

Establishment of AIS is not only dependent upon the frequency of introduction but the convergence of optimal physical and chemical factors (e.g., fine substrates, particulate organics, available calcium, et cetera.). Partitioning of optimal habitat can vary temporally and would enable critical life stages to survive and either complete a life cycle at the same location or enable migration to other locations that are more suitable for completion of remaining life stages (excluding invasive macrophyte species). Surveys of these optimal habitat zones should be conducted on a routine basis to identify new AIS infestations or areas where they could establish.

Strategy D2: Existing AIS

Understanding the distribution and impacts of existing AIS (i.e., Species Management Types 2, 3, 4) may be used as a benchmark for future management assessments and prioritization.

Actions

D2a. Invertebrate Monitoring Plan

Describe invertebrate monitoring protocols and current distributions. Review monitoring protocols as needed. Develop a site selection process that targets at-risk habitats from invasion of invertebrate AIS. Select protocols that measure appropriate habitat features that would be used by invertebrate AIS. Prepare a Quality Assurance Project Plan (QAPP) as part of a long-term monitoring program. Determine associations with other invasive species that provide habitat structure or physical features along the shoreline that would serve as suitable habitat for colonization.

D2b. Aquatic Plant Monitoring Plan

Continue to map the distribution of aquatic plants with annual surveys and identify likely locations of infestation within the Region. Determine associations with other invasive species that provide habitat structure or physical features along the shoreline (e.g., sediment types) that would serve as suitable habitat for colonization.

D2c. Warm Water Fish Monitoring Plan

Continue to identify habitats that currently support and are predicted to support all life stages of non-native warm water fish. Determine associations with other invasive species that provide habitat structure (e.g., Eurasian watermilfoil) or physical features along the shoreline that would serve as suitable habitat for colonization.

D2d. Bullfrog Monitoring Plan

Through partnerships, develop a plan to identify and survey at-risk habitat for bullfrog invasions in the Region. Determine associations with other invasive species that provide habitat structure (e.g., Eurasian watermilfoil) or physical features along the shoreline that would serve as suitable habitat for colonization.

Strategy D3: Early Detection and Rapid Response (EDRR) Planning

The purpose of developing early detection and rapid response (EDRR) plans is to provide for a coordinated system to monitor, report, and effectively respond to newly discovered and localized invasive species (NISC 2008). Critical to the success of EDRR plans is the ability to share resources across jurisdictional boundaries, establishment of strategic partnerships, available funds and technical resources, and mutually agreed upon implementation plans. The NISC breaks EDRR into the following three components:

- Early Detection (ED): where targeted species surveys and localized monitoring efforts are used to construct distribution maps and other ecological/biological data to facilitate planning and response actions.
- Rapid Assessment (RA): where the appropriate response to the ED and an overall strategy is formulated; accounting for "transjurisdictional issues".
- Rapid Response (RR): where localized populations of invasive species are systematically eradicated or contained, including newly discovered as well as expanding populations of existing invasives.

The *Draft California AIS Rapid Response Plan* was developed to address general AIS issues in the state (CDFG 2008) and is based on the incident command system (ICS) where "participants are assigned specific roles in a well-defined hierarchical system that can be expanded or collapsed based on the size and complexity of the incident." ICS is now integrated into the National Incident Management System (NIMS) that

> "…provides a systematic, proactive approach to guide departments and agencies at all levels of government, nongovernmental organizations, and the private sector to work seamlessly to prevent, protect against, respond to, recover from, and mitigate the effects of incidents, regardless of cause, size, location, or complexity, in order to reduce the loss of life and property and harm to the environment."

The Columbia River Basin (CRB) Team of the 100th Meridian Initiative recently prepared a working draft of the *Columbia Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other* Dreissenid *Species* that similarly follows the management structure requirements of the NIMS (Columbia River Basin Team 2008). The Columbia River Basin Team identified ten response objectives to support their goal of delineating and controlling dreissenid mussel populations:

1. Make initial notifications
2. Activate appropriate organizational elements of the CRB Interagency Response Plan
3. Verify reported introduction
4. Define extent of colonization
5. Establish external communications system
6. Obtain and organize resources
7. Prevent further spread via quarantine and pathway management
8. Initiate available/relevant control actions
9. Institute long-term monitoring
10. Evaluate the Response Plan

Actions

D3a. Lake Tahoe Region AIS EDRR Plan

Develop a *Lake Tahoe Region AIS EDRR Plan* to address a broad range of potential AIS. The Plan may be modeled after the Draft *California Rapid Response Plan* (CDFG 2008) and the *Columbia Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other* Dreissenid *Species* but tailored to the unique jurisdictional authority of agencies in the Lake Tahoe Region. Adopt National Incident Command System as part of the EDRR framework.

D3b. Lake Tahoe Region Mussel EDRR Plan

Complete the *Lake Tahoe Region Mussel EDRR Plan* modeled after the Draft *California Rapid Response Plan* (CDFG 2008), the *Columbia Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other* Dreissenid *Species* (Columbia River Basin Team 2008), and the draft *Quagga-Zebra Mussel Action Plan* (WRP 2009), but tailored to the unique jurisdictional authority of agencies in the Lake Tahoe Region. Adopt National Incident Command System as part of the EDRR framework.

D3c. Rapid Response Drill

Trigger yearly rapid response drill for AIS using ICS protocols.

D3d. Plan Review

Review the *Lake Tahoe Region AIS EDRR Plan* and the *Lake Tahoe Mussel Rapid Response Plan* every two years by a LTAISCC sub-committee.

Strategy D4: Funding

Accessible and sufficient funding is critical to implementing EDRR elements, including those elements identified in under Strategy D3.

Actions

D4a. Establish Sustainable Funding Mechanisms

Establish monetary means to rapidly implement and sustain elements of the response plans named in D3a and D3b. Evaluate the use of boating fee/permits, fuel add-ons, and launch surcharges to provide financial support to AIS response efforts.

6.5 Objective E: Long-term Control/Eradication

Control of AIS implies that populations are present and small enough to curtail further increases while eradication means complete removal of all life stages of a species (see section 2 AIS Management Approach). Often the methods to control AIS are the same as those to eradicate an AIS, however, the methods are applied differently or used in a fully-integrated eradication regime. That is, the intensity of management may vary greatly from control to eradication. Methods to control or eradicate may overlap between groups of AIS while other methods are specific to a particular AIS.

Strategy E1: Aquatic Plant Control/Eradication

Each action should include an evaluation of effectiveness and ability to measure success in controlling and/or eradicating invasive aquatic plants. Options currently available to control or eradicate invasive aquatic plants in the Tahoe Region include physical and mechanical methods.

Actions

E1a. Tahoe Keys Aquatic Plant Management Plan

Develop and implement an aquatic plant management plan specific to the Tahoe Keys. Elements of the plan should include measures to

- Prevent spread of existing invasive aquatic plants populations beyond the Tahoe Keys
- Prevent the introduction of additional invasive plant species
- Determine long-term control or eradication goals for the Tahoe Keys using all available technologies (see Strategy G3: Provide for All Appropriate Treatment and Control Measures)

E1b. Benthic Barriers

Continue the use of benthic barriers to control unwanted aquatic vegetation in open areas where submersed wood and recreational activities would not impede efficacy.

E1c. Hand-pulling

Continue the use of hand-pulling, along with diver-operated suction if appropriate, in those areas where benthic barriers cannot be safely or effectively deployed.

E1d. Diver-operated Suction

Continue use of diver-operated suction to assist hand-pulling efforts as described in E1c.

E1e. Mechanical Harvesting

Where mechanical harvesting is used, continue to incorporate best management practices to ensure plant fragments are collected to prevent further spread.

E1f. Aquatic Herbicides

Continue efforts to provide for all available control technologies, including the use of aquatic herbicides to control Eurasian watermilfoil and curlyleaf pondweed (Strategy G3) by working closely with the LRWQCB. Establish protocols to isolate drift and reduce deleterious impacts to non-target organisms by incorporating best management practices.

E1g. Eradication Plan

For eradication projects, develop a plan that includes long-term monitoring, prevention, and rapid response to re-occurring infestations.

Strategy E2: Asian Clam Control/Eradication

Each action should include an evaluation of effectiveness and ability to measure success in controlling and/or eradicating Asian clams. Options currently available to control Asian clams in Lake Tahoe include physical and mechanical methods; however, these methods are under development and not yet operational lake-wide.

Actions

E2a. Pilot Asian clam control/eradication project

Continue to evaluate the logistics, effectiveness, and environmental impacts of using diver-operated suction and benthic barriers for Asian clam removal. More specifically, evaluate if re-suspended sediment in the water column can liberate sufficient organics to promote the growth of other AIS or algae.

E2b. Molluscicides

Provide for all available control technologies, including the use of molluscicides to control Asian clams (Strategy G3). Establish protocols to isolate drift and reduce deleterious impacts to non-target organisms by incorporating best management practices.

E2c. Eradication Plan

For eradication projects, develop a plan that includes long-term monitoring, prevention, and rapid response to re-occurring infestations.

E2d. Lakewide Asian clam Survey

Determine the distribution of Asian clams in Lake Tahoe using an autonomous underwater vehicle (AUV) called the "Gavia" (http://gavia.is/) which will be used to take high resolution photography of the lake bottom to look for surficial clam shells as an indicator of live Asian clam presence.

Strategy E3: Warm Water Fish Control/Eradication

Each action should include an evaluation of effectiveness and ability to measure success in controlling and/or eradicating warm water fish. Continued information about juvenile, subadult and adult life stages is essential for adapting various control/eradication strategies and methods. Control/eradication strategies and methods will need to be consistent with state and federal fisheries management objectives (i.e., threatened and endangered species recovery programs) and. For warm water fish control projects implemented on the Nevada side of Lake Tahoe, a scientific collection permit may be required as some warm water fish species are considered "game fish" according to NAC 503.060.

Actions

E3a. Tagging

Continue to monitor the movement of warm water invasive fish in Lake Tahoe and determine the spatial and temporal use of habitats to complete all life stages.

E3b. Tahoe Keys AIS Control and Demonstration

Determine how warm water fish respond to the removal of invasive aquatic plants in the Tahoe Keys. Conduct a dye study to determine residence time and water movement patterns in selected high priority sites in the Tahoe Keys for herbicide application.

E3c. Electro-fishing

Incorporate the use of electro-fishing to control invasive warm water fish from habitats identified through the tagging program (Action E3a).

E3d. Netting

Evaluate the use of nets to control invasive warm water fish from habitats identified through the tagging program (Action E3a).

E3e. Piscicides

Continue to provide for all available control technologies, including the use of piscicides (i.e., rotenone) to control warm water fishes (Strategy G3). Variance criteria for piscicide use are provide in the Basin Plan. Establish protocols to isolate drift and for neutralization, and reduce deleterious impacts to non-target organisms by incorporating best management practices.

E3f. Eradication Plan

For eradication projects, develop a plan that includes long-term monitoring, prevention, and rapid response to re-occurring infestations.

Strategy E4: Bullfrog Control/Eradication

Each action should include an evaluation of effectiveness and ability to measure success in controlling and/or eradicating bullfrogs. Current efforts to control bullfrogs from the Region are limited and much work is needed to determine the most appropriate methods based on current population sizes and locations.

Actions

E4a. Evaluate Bullfrog Control/Eradication Methods

Evaluate the success of various methods to control/eradication bullfrogs.

E4b. Habitat Restoration to Support Native Amphibians

Implement restoration projects using data from D2d to restore habitat for native amphibians.

E4c. Eradication Plan

For eradication projects, develop a plan that includes long-term monitoring, prevention, and rapid response to re-occurring infestations.

6.6 OBJECTIVE F: RESEARCH AND INFORMATION TRANSFER

Research is critical to identifying environmental requirements and survivability thresholds of AIS and determining appropriate and innovative management techniques.

Strategy F1: Detection Technology

Continuing to identify and incorporate methods to detect various life stages of AIS is critical to improving rapid response and eradication. These technologies will improve the likelihood of identifying cryptic or microscopic life stages prior to a wide-spread infestation.

Actions

F1a. Innovative Technologies to Detect AIS

Continue to identify innovative technologies to detect AIS, i.e., PCR analysis, DNA testing, sonar/acoustic development for invertebrates and plants on a fine scale.

F1b. Alternative AIS Vectors

Continue to determine mechanisms for AIS introduction to the Region and continue to identify life stages more amenable to transport to and survival in the Region.

F1c. Prioritize AIS Management Efforts

Continue to prioritize AIS prevention, education, monitoring, control, and research efforts in order to implement strategies in an economical and effective manner. Determining the order for implementation of management actions will provide longer term effectiveness from re-occurrence.

Strategy F2: AIS Life Histories and Environmental Requirements

Successful prevention and control efforts are largely dependant upon understanding the life histories and environmental requirements of current or potential AIS. Conducting research or compiling information that facilitates this understanding is considered a high priority in the Region.

Actions

F2a. Calcium Sampling

Continue calcium sampling in Lake Tahoe and expand to other waterbodies in the Region to determine potential dreissenid mussel habitat.

F2b. Survivability

Continue to identify controlling and limiting factors for survival and proliferation for all life stages of existing and potential AIS, including plants, fishes, and invertebrates.

F2c. Risk Matrix

Develop a detailed substrate/energy matrix that identifies at-risk sites for expansion of existing and establishment of potential AIS.

Strategy F3: Research Needs

Research aimed at addressing species interactions, the ecological effects of control measures, potential sites for new invasions, and sources of funding are critical to preventing the spread and introduction of AIS to the Region. Future revisions of the Plan should carefully examine research needs based on adaptive management approaches.

Actions

F3a. Lake Tahoe AIS Research

Continue to foster research interest in the prevention, impacts and control of AIS in the Tahoe Region.

F3b. Yearly Workshop

Continue the LTAISWG yearly workshops to identify knowledge gaps and associated prevention, education, monitoring, control, and research needs as related to AIS in the Region.

F3c. Interactions of Native to Non-native and Native to Native Species

Continue to evaluate not only how native species are impacted by non-native species, but how native species can similarly impact other species. For example, when the growth of native species becoming noxious or problematic.

F3d. Evaluate Removal Disturbance

Continue to examine how removal efforts may result in disturbance processes and increase the likelihood of creating more invasions.

F3e. Species Facilitation of AIS Establishment

Continue to determine the extent to which existing AIS (e.g., Asian clams, aquatic weeds) facilitate the establishment of new AIS.

F4f. Global Climate Change and AIS Establishment

Evaluate the effects of global change on water quality and the establishment success of new AIS.

F3g. Sites for Intra- and Inter-region Invasion

Determine vulnerable areas for within-lake invasion based on physical or chemical attributes (i.e., sediment type, protection from wave action, dissolved ions) and areas that serve as sources of invasive species for other parts of Lake Tahoe and other water bodies within the Region (e.g, Fallen Leaf Lake).

F3h. Research Funding

Continue to use the LTAISWG to prioritize research needs and identify and coordinate research funding.

Strategy F4: Information Transfer

The open exchange of information between regional, state, national, and even international resource managers is critical to staying apprise of AIS issues elsewhere. This is particularly important for the Tahoe Region because so many recreationalists visit Lake Tahoe from elsewhere.

Actions

F4a. Communication between Regional and State AIS

Improve communication about AIS activities in the Tahoe Region between the LTAISCC and state AIS activities (i.e., CAAIST and CDFG).

F4b. List of AIS Experts

Maintain list of AIS experts available to rapidly identify new AIS.

6.7 Objective G: Laws & Regulations

In the Lake Tahoe Region, laws and regulations limiting the possession, transportation, introduction, distribution, propagation, control, et cetera of AIS are overseen by numerous agencies at the regional (i.e., TRPA), state (e.g., CDFG, CDFA, NDOW, NDA), and federal (e.g., USDA) levels. The diverse legal landscape in the Lake Tahoe Region, has led to substantial gaps in AIS laws and regulations, particularly given the bi-state nature of the Region.

Strategy G1: AIS Lists

Maintain accurate lists of AIS to alert managers and watercraft inspectors to species either present or threatening introduction to the Lake Tahoe Region.

Actions

G1a. CDFA Weed Ratings

Partner with CDFA to increase the number of aquatic plants on the “A” list of noxious weeds (Table 6). Currently, neither curlyleaf pondweed nor Eurasian watermilfoil are included on the CDFA Noxious Weed List.

G1b. NDA Noxious Weed List

Partner with NDA to increase the number of aquatic plants on the "A" list of noxious weeds (Table 6). Currently, Eurasian watermilfoil is listed as an "A" category noxious weed according to the NDA; however, curlyleaf pondweed is not.

G1c. Tahoe-specific Prohibited AIS

Create a list of AIS prohibited from the Tahoe Region. Such a list would greatly benefit watercraft inspectors, resource managers, and law enforcement.

Strategy G2: Existing Laws and Regulations

Given the bi-state nature of the Tahoe Region, efforts should be made to ensure that existing AIS laws and regulations are consistent or at least not in conflict between the States of California and Nevada, the federal government, and this Plan.

Actions

G2a. Regional, State and Federal AIS Laws

Identify gaps and overlap in existing AIS laws, including but not limited to, quarantine, decontamination, possession, transport, and introduction. Determine the factors that limit enforcement capacity and how communication between policy makers and enforcement officers may be improved.

G2b. Amendments

Provide recommendations to policy makers to bolster existing laws and establish Region-wide consistency. For example, allow Nevada law enforcement to quarantine mussel-infested vessels similar to that allowed by California DFG Code §2301 (see Appendix A).

G2c. Coordinate CA and NV Law Enforcement

Facilitate the alignment of the TRPA and the States of California and Nevada's rules on AIS transport, possession, and introduction to establish Region-wide rules (summarized in Appendix A).

Strategy G3: Provide for All Appropriate Treatment and Control Measures

At present, the use of aquatic pesticides to control or eradicate AIS in the Lake Tahoe Region is essentially unavailable to resource managers (see LRWQCB in Appendix A). Discussions between the LTAISCC and the LRWQCB should continue in an effort to provide for all available and appropriate technologies to meet the management goals of this Plan.

Actions

G3a. Acceptable Approaches to Treatment

Continue discussions with the LRWQCB to determine the most acceptable direction for providing all available AIS control methods, including the use of EPA-approved aquatic herbicides.

G3b. Environmental Documentation for Aquatic Pesticide Use

Determine the necessary environmental documentation to allow for the application of registered aquatic pesticides (herbicides, mulluscicides, fungicides, and insecticides) in the Tahoe Region. Particular emphasis shall be on the Basin Plan and 208 Plan (see Appendix A). To control invasive fish, resource managers can currently request a variance from the LRWQCB to allow application of the piscicide, rotenone.

G3c. Public Awareness

Provide outreach and education to agencies and policy makers about the need to utilize all available and appropriate technologies to control or eradicate selected AIS from the Tahoe Region. Outreach and education efforts may be accomplished, for example, through workshops (Action F4b) and signage.

7 Implementation Table

Descriptions of the objectives, strategies, and actions above provide background and justification of each action item. The implementation table identifies additional important elements of each action item, including: the lead and cooperating entities, priority levels, current funding levels and, where known, anticipated funding needs over the period 2010 to 2015 (Table 8).

Table 8. Lake Tahoe Region AIS Management Plan Implementation Table

Objectives/Strategies/Actions		Lead Entity	Coop. Entity	Priority	Current/ Short-term need $1K	FY10-15 Anticipated need $1K	Current Fund Source
Objective A: Management Plan Implementation and Updates							
Strategy A1: Oversight and Implementation							
A1a	Development of Lake Tahoe Region AIS Management Plan	USACE, Tt	LTAISCC	High	$363	-	USACE
A1b	Lead Organization for Plan Oversight	TRPA	LTAISCC	High	-	$500 (1.0 FTE)	-
A1c	Implementation of the Lake Tahoe Region AIS Management Plan	TRPA	LTAISCC, LTAISWG	High	-	$	
A1d	Funding for ANS Coordinator	USFWS	LTAISCC, LTFAC	High	$200	$600	Multiple sources
A1e	Fiscal Agent for Plan	TRPA		High	-		-
Strategy A2: Review Process							
A2a	LTAISCC Review Sub-committee	LTAISCC		High	-	-	TRPA, USFWS, NDOW, CDFG, USDA-ARS, LRWQCB
A2b	LTAISCC Sub-committee Review	LTAISCC	TSC	Med	-	$4	
A2c	Plan Revision	LTAISCC	-	High	-	$50	
A2d	Considerations for Plan Revision	LTAISCC		High	-	-	-
Strategy A3: Funding							
A3a	Establish LTAISCC Financial Sub-committee	LTAISCC	TRPA	High	-	-	-
Objective B: Coordination and Collaboration							
Strategy B1: Regional, Bi-state, National and International							

Table 8 cont.

Objectives/Strategies/Actions		Lead Entity	Coop. Entity	Priority	Current/ Short-term need $1K	FY10-15 Anticipated need $1K	Current Fund Source
B1a	Nevada AIS Management Plan	NDOW	LTAISCC, multiple NV agencies	High	$250	$	-
B1b	LTAISCC and LTAISWG	TIE	LTFAC	High	-	-	-
B1c	Annual LTAISWG Reports	LTAISWG	-	Med	$1	$5	Multiple sources
B1d	Foster Shorezone Partnerships	TRCD	LTAISWG	High	$20	$100	Multiple sources
B1e	Link LTAISCC to State, National, and International AIS Groups (Host Conference)	LTAISCC	-	Med	-	$30	-
Objective C: Prevention							
Strategy C1: Inspection and Decontamination							
C1a	Vessel Inspection Plan	TRCD	CTC, USACE, TRPA, USFWS	High	$980	$700-$1M/year (includes private, local, federal shares; Shared with C1d)	USACE, TRF, IVGID, SNPLMA (Rd. 8)
C1b	Fee-based System to Support VIP	TRPA	LTASICC	High	$5	$125	TRPA
C1c	Small Watercraft Screening	USFS-LTBMU	LTAISWG	High	$3	$40	USFS-LTBMU
C1d	Non-motorized Watercraft Inspection	LTAISWG	-	High	-	Shared with Strategy C1a	-
C1e	Evaluate Decontamination Methods	LTAISWG	-	High	-		-
C1f	Ensure Decontamination of a Range of Equipment	LTAISWG	-	High	-		-
C1g	Ensure Decontamination of a Range of AIS	TRPA			-		-

Table 8 cont.

Objectives/Strategies/Actions		Lead Entity	Coop. Entity	Priority	Current/ Short-term need $1K	FY10-15 Anticipated need $1K	Current Fund Source
C1h	Develop Professional AIS Inspector Program	LTAISCC	-	Low	-	$10	-
C1i	National and International Contacts	LTAISWG	USFWS	High	-	-	-
Strategy C2: Pathways/Vectors							
C2a	Boaters	LTAISWG	-	High	-		-
C2b	Anglers	LTAISWG	-	High	-		-
C2c	Natural Resource Management	LTAISWG	-	High	-		-
C2d	Wildfire Suppression Activities	USFS-LTBMU	LTAISCC	High	-	$50	-
C2e	Construction Activities	LTAISWG	-	High	-	-	Funded through VIP
C2f	Fish Stocking	CDFG, NDOW	USFWS		-		-
C2g	AIS Identification	TRCD			-		-
Strategy C3: Education							
C3a	LTAISWG Education/Outreach Plan	TRCD, TRPA	CTC, USFWS	High	$25	-	USACE
C3b	Stop Aquatic Hitchhikers! Campaign	LTAISWG	-	High	$250 (Shared with remaining C3 actions)	$1M (Shared with remaining C3 actions and G3c)	Multiples sources
C3c	Habitattitude National Public Awareness Campaign	LTAISWG		Med	Shared with C3b	Shared with C3b	Multiples sources
C3d	Press Releases	LTAISWG	-	High	-	-	-
C3e	Advertising and Publications	LTAISWG	-	High	Shared with C3b	Shared with C3b	Multiples sources

Table 8 cont.

	Objectives/Strategies/Actions	Lead Entity	Coop. Entity	Priority	Current/ Short-term need $1K	FY10-15 Anticipated need $1K	Current Fund Source
C3f	National and International Contacts	LTAISWG	-	Med	-	-	-
C3g	Aquascaping	TRCD	TRPA		Shared with C3b	Shared with C3b	Multiples sources
C3h	AIS Hotlines	TRCD, USFWS			Shared with C3b	Shared with C3b	Multiples sources
Objective D: Monitoring, Detection, and Response							
Strategy D1: Potential AIS							
D1a	At-risk Waterbodies in Region	LTAISWG	-	High	-	$150	-
D1b	Volunteer AIS Monitoring	TRCD	-	High	-		-
D1c	AIS-infested Waterbodies	TRPA (TIIMS)	Various agencies contribut e	High	-		-
D1d	At-risk In-lake Habitats	LTAISWG			-		-
Strategy D2: Existing AIS							
D2a	Invertebrate Monitoring Plan	TERC, TRPA	CTC	High	$3.5K	-	USACE
D2b	Aquatic Plant Monitoring Plan	TRCD	CADSP, CSLC Remetrix, TRPA	High	$250K		USBOR
D2c	Warm Water Fish Monitoring Plan	USFS-LTBMU	CDFG, UNR, UCD		$40	$100	Multiple sources
D2d	Bullfrog Monitoring Plan	LTAISWG, USFS-LTBMU			-	$35	-

Table 8 cont.

Objectives/Strategies/Actions		Lead Entity	Coop. Entity	Priority	Current/ Short-term need $1K	FY10-15 Anticipated need $1K	Current Fund Source
Strategy D3: Early Detection and Rapid Response (EDRR) Planning							
D3a	Lake Tahoe Region AIS EDRR Plan	USFWS			-	$	-
D3b	Lake Tahoe Region Mussel EDRR Plan	USFWS	LTAISCC, LTAISWG, FTFAC	High	Agency supported	$25	USFWS
D3c	Rapid Response Drill	USFWS	Various agencies	High	-	$7	-
D3d	Plan Review	LTAISCC	LTAISCC, LTAISWG	High	-	$	-
Strategy D4: Funding							
D4a	Evaluate Sustainable Funding Mechanisms	USFWS	LTAISCC	High	-		-
Objective E: Long-term Control/Eradication							
Strategy E1: Aquatic Plant Control/Eradication							
E1a	Tahoe Keys Aquatic Plant Management Plan	TRCD, USDA-ARS		High	-	$50	-
E1b	Benthic barriers	TRCD	TDC, TRPA, CSLC		$250 (shared with E1c, E1d)		USBOR, CSL
E1c	Hand-pulling	LTAISWG			$250 (shared with E1b, E1d)		USBOR, CSL
E1d	Diver-operated suction	LTAISWG	TDC		$250 $250 (shared with E1b, E1c)		USBOR, CSL
E1e	Mechanical harvesting	TKPOA			$250	$1.3M	TKPOA

Table 8 cont.

Objectives/Strategies/Actions		Lead Entity	Coop. Entity	Priority	Current/ Short-term need $1K	FY10-15 Anticipated need $1K	Current Fund Source
E1f	Aquatic herbicides	LTAISWG	-	High	-	See: Gaps and Challenges	-
E1g	Eradication Plan	TRCD, USDA-ARS			-		-
Strategy E2: Asian Clam Control/Eradication							
E2a	Pilot Asian clam control/eradication project	LTAISWG		High	$503 (Shared with E2c)	-	USBOR, NDSL, LRWQCB, SNPLMA
E2b	Molluscicides	LTAISWG		High	-		-
E2c	Eradication Plan	LTAISWG			Shared with E2c	-	-
E2d	Lakewide Asian clam survey	LTAISWG		High	$125	-	LRWQCB, NSL
Strategy E3: Warm Water Fish Control/Eradication							
E3a	Tagging	USFS-LTBMU, UNR			$60	$250	SNPLMA and other multiple sources
E3b	Tahoe Keys AIS Control and Demonstration	USFS-LTBMU	USFWS	High	$464	-	SNPLMA
E3c	Electro-fishing	USFS-LTBMU, UNR, CDFG			-	$3.6 M	-

Table 8 cont.

Objectives/Strategies/Actions		Lead Entity	Coop. Entity	Priority	Current/ Short-term need $1K	FY10-15 Anticipated need $1K	Current Fund Source
E3d	Netting	USFS-LTBMU, UNR			-	$1.8 M	-
E3e	Piscicides				-	$720	-
E3f	Eradication Plan	USFS-LTBMU, UNR			-	$	-
Strategy E4: Bullfrog Control/Eradication							
E4a	Evaluate Bullfrog Control/Eradication Methods	LTAISWG, USFS-LTBMU			-	$70	-
E4b	Habitat Restoration to Support Native Amphibians	LTAISWG, USFS-LTBMU			-	$150	-
E4c	Eradication Plan	LTAISWG, USFS-LTBMU			-	$40	-
Objective F: Research and Information Transfer							
Strategy F1: Detection Technology							
F1a	Innovative Technologies to Detect AIS	LTAISWG	LTAISCC	High	-		-
F1b	Alternative AIS Vectors	LTAISWG		High	-		-
F1c	Prioritize AIS Management Efforts	LTAISWG	LTAISCC	High	Included in Plan	-	USACE
Strategy F2: AIS Life Histories and Environmental Requirements							

Table 8 cont.

Objectives/Strategies/Actions		Lead Entity	Coop. Entity	Priority	Current/ Short-term need $1K	FY10-15 Anticipated need $1K	Current Fund Source
F2a	Calcium sampling	TERC, UNR, TRPA	CTC	High	$92K	-	USACE
F2b	Survivability	TERC, TRPA, UNR	CTC, TSC	High	$48K	-	USACE
F2c	Risk Matrix	LTAISCC			-	$	-
Strategy F3: Research Needs							
F3a	Lake Tahoe AIS Research	TSC	LTAISCC, LTAISWG	High	-		-
F3b	Yearly workshop	LTAISWG	Various agencies	High	$	$	
F3c	Interactions of Native to Non-native and Native to Native Species	LTAISCC	TSC	Med	-	$	-
F3d	Evaluate Removal Disturbance	LTAISWG	TRPA	High		$	
F3e	Species Facilitation of AIS Establishment	LTAISWG		High	$20	-	USACE
F3f	Global Climate Change and AIS Establishment	LTAISWG		Med	-	$	-
F3g	Sites for Intra- and Inter-region Invasion	LTAISWG		High	-	$	-
F3h	Research Funding	LTAISWG		High	-	-	-
Strategy F4: Information Transfer							
F4a	Communication Between Regional and State AIS Activities	LTAISCC	USFWS	High	-	$5	-
F4b	List of AIS Experts	USDA-ARS	LTAISCC	Med	-	$5	-
Objective G: Laws and Regulations							
Strategy G1: AIS Lists							
G1a	CDFA Weed Ratings	TSC	LTAISCC	High	-		-

Table 8 cont.

Objectives/Strategies/Actions		Lead Entity	Coop. Entity	Priority	Current/ Short-term need $1K	FY10-15 Anticipated need $1K	Current Fund Source
G1b	NDA Noxious Weed List	TRPA, USFWS	LTAISCC	High	-		-
G1c	Tahoe-specific Prohibited AIS	LTAISCC	TSC	High	-		-
Strategy G2: Existing Laws and Regulations							
G2a	Regional, State and Federal AIS Laws	LTFAC	LTAISCC	High	-		-
G2b	Amendments	LTAISCC	LTAISCC	High	-		
G2c	Coordinate CA and NV Law Enforcement	LTAISCC		High	-		-
Strategy G3: Provide for All Appropriate Treatment and Control Methods							
G3a	Acceptable Approaches to Treatment	LTAISCC		High	-		-
G3b	Environmental Documentation for Aquatic Pesticide Use	LRWQCB, USFS-LTBMU, TRPA	-	High	-	$325K	-
G3c	Public Awareness	LTAISWG	LTAISCC	High	Shared with C3b	Shared with C3b	-

8 Plan Review

Review of the Plan will be directed by the LTAISCC. The breadth of experience and representation on the LTAISCC allows for comprehensive guidance for subsequent Plan review. A subcommittee will be formed to provide an annual review and determine whether a formal revision is required to meet the emerging prevention, monitoring, control, education, and research needs in the Region. If needed, the subcommittee will revise the Plan every five years following the ANSTF's *Guidance for State and Interstate Aquatic Nuisance Species Management Plans*. Considerations for annual reviews and revision should address:

- The effectiveness of education and prevention efforts and the efficacy of control/eradication methods
- The number of new introductions
- Allocation of funds consistent with the objectives of the Plan
- New vector pathways
- Table 6: species list, management types, presence/absence, pathways of introduction, and applicable pest ratings
- Necessary environmental documentation to allow for all control/eradication methods
- Gaps and challenges in regional, state, and federal regulations related to AIS introduction, spread, and control/eradication
- Early detection and rapid response protocols
- Adaptive management approaches and their use during Plan revision
- Known or potential effects from climate change on AIS
- Efforts to inspect and decontaminate all vectors (e.g., small watercraft, fishing equipment)

9 Research Considerations

The following research gaps have been identified and should be considered for future funding and Plan revisions. These gaps were determined from literature reviews of AIS currently in or threatening the Region and those identified by researchers and resource managers:

Environmental

- Are calcium levels in Lake Tahoe adequate to support all life stages of quagga/zebra mussels (this work in currently underway at UNR)?
- How do seasonal changes in calcium concentration affect mussel survivability (question being addressed by UNR)?
- Are concrete structures substantial sources of calcium to facilitate dreissenid mussel establishment?

- What are other substantial sources of calcium to Lake Tahoe that could support dreissenid mussel establishment?
- What are the spawning cycles of largemouth bass and other warm water fishes in Lake Tahoe?
- Are there unique microhabitats in the Region that would allow otherwise unpredictable invasions, e.g., geothermal springs?
- Is the algal assemblage in Lake Tahoe sufficient to support invertebrate growth and reproduction?
- Will physical habitat in the Lake Tahoe be limiting to quagga and zebra mussels?
- What causes the massive die-offs of signal crayfish along the west shore of Lake Tahoe?
- What are the impacts of signal crayfish on sedimentation and water clarity?
- Which waterbodies in the Tahoe Region are at risk for New Zealand mudsnail invasion?
- What other areas of Lake Tahoe physically resemble those currently inhabited by Asian clams? And, are chemical conditions limiting to survival of Asian clams in these areas?

Management

- Will management strategies for existing AIS alter Lake Tahoe water quality, food web structure, and benthic ecology?
- How can IPM be better incorporated into AIS control/eradication efforts?

Interaction with Other Existing AIS

- Can nearshore habitats currently infested with AIS (e.g., Eurasian watermilfoil, Asian clams) facilitate the establishment of other AIS (e.g., quagga/zebra mussels, New Zealand mudsnails, and hydrilla)?
- How does competition with other invasive species (bivalves and macrophytes) affect ability to colonize or to maintain established colonies of Asian clams?
- What is the energetic contribution of signal crayfish to predatory warm water fishes such as largemouth bass?
- Will Asian clam removal facilitate recolonization by Asian clams or other invasive species (e.g., aquatic weeds, dreissenid mussels)?
- Are there potential predators of the New Zealand mudsnail currently in Lake Tahoe?
- How do established colonies of New Zealand mudsnails affect potential colonization for other invasive species?

Surveys

- Survey tributaries to Lake Tahoe and other waterbodies in the Region for AIS such as New Zealand mudsnails, Asian clams, and non-native submersed aquatic plants.
- What is the level of *Batrachochytrium dendrobatidis* (Bd) infection in native amphibian populations and their habitats?

Vector Pathways

- Examine new vector pathways for existing species of concern.
- What are the primary pathways of AIS introduction to Lake Tahoe in addition to motorized watercraft?
- What are the likely pathways of New Zealand mudsnail introduction to Lake Tahoe?

Climate Change

- What is the response of warm-water fishes and bullfrog in Lake Tahoe to regional/local climate change (UCD 2008)?
- Will physicochemical factors resulting from climate change enhance potential for successful colonization of new AIS?

10 Literature Cited

Anderson, L.W.J. 2007. Status of Invasive Aquatic Plants at Lake Tahoe: Eurasian watermilfoil and Curlyleaf pondweed. Report to Aquatic Invasive Species Workshop. Lake Tahoe.

ANSTF (Aquatic Nuisance Species Task Force). 2007. Strategic Plan 2007-2012. http://www.anstaskforce.gov/Documents/ANSTF_Strategic_Plan_2007_Final.pdf

Bierwagen, B.G., R. Thomas, and A. Kane. 2008. Capacity of management plans for aquatic invasive species to integrate climate change. Conservation Biology 22(3): 568-574.

Boelman, S.F., F.M. Neilson, E.A. Dardeau, Jr., and T. Cross. 1996. Zebra mussel (*Dreissena polymorpha*) Control Handbook for Facility Operators, First Edition. Misc. Paper EL-97-1. U.S. Army Engineers Waterways Experiment Station, Vicksburg, MS.

Boylen, C.W., L.W. Eichler, and J.D. Madsen. 1999. Loss of native aquatic plant species in a community dominated by Eurasian watermilfoil. Hydrobiologia. 415:207-211.

Bryon, E.R., C.L. Folt, and C.R. Goldman. 1984. Copepod and cladoceran success in an oligotrophic lake. Journal of Plankton Research 6(1): 45-65.

CDFG (California Department of Fish and Game). 2008. California Aquatic Nuisance Species Management Plan. http://www.dfg.ca.gov/invasives/plan/AISMgmtPlan.pdf

CRWQCB (California Regional Water Quality Control Board). 2005. Water Quality Control Plan for the Lahontan Region North and South Basins. California Regional Water Quality Control Board: Lahontan Region.

Carlton, J.T. 2001. Introduced Species in U.S. Coastal Waters: Pew Oceans Commissions Report. Pew Oceans Commissions: Washington, DC.

Carignan, R. and J. Kalff. 1980. Phosphorus sources for aquatic weeds: water or sediments? Science. 207(4434):987-989.

Chambers, P.A. and J. Kalff. 1985. Depth distribution and biomass of submersed aquatic macrophyte communities in relation to secchi depth. Canadian Journal of Fisheries and Aquatic Sciences. 4(4):701-709.

Chandra, S., K.L.C. Ngai, M. Kamerath, and B. Allen. 2009. Warm-water non-native fishes in Lake Tahoe. Report prepared for Elizabeth Harrison, Nevada State Lands.

Closs, G.P., B. Ludgate, and R.J. Goldsmith. 2003. Controlling European perch (*Perca fluviatilis*): lessons from an experimental removal. *In:* Managing Invasive Freshwater Fish in New Zealand. Department of Conservation. Hamilton, New Zealand.

Coats, R., J. Perez-Losada, G. Schladow, R. Richards, and C. Goldman. 2006. The warming of Lake Tahoe. Climate Change 76(1-2):1573-1480.

Cohen, A.N. and J.T. Carlton. 1998. Accelerating invasion rate in a highly invaded estuary. Science 279(5350): 555-558.Coffin, P.D. and W.F. Cowan. 1995. Recovery plan for the Lahontan cutthroat trout. U.S. Fish and Wildlife Service. Portland, OR.

Cohen, A.N. 2007. Potential Distribution of Zebra Mussels (*Dreissena polymorpha*) and Quagga Mussels (*Dreissena bugensis*) in California: Phase 1 Report. California Department of Fish and Game. San Francisco Estuary Institute. Oakland, CA.

Columbia River Basin, 100th Meridian Initiative. 2008. Columbia River Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other *Dreissenid* Species.

Cooke, D.G., E.B. Welch, S.A. Peterson, and S.A. Nichols. 2005. Restoration and Management of Lakes and Reservoirs. 3rd Editor. Taylor and Francis, Boca Raton. 591 pp.

Cordone, A.J., and T.C. Frantz. 1966. The Lake Tahoe sport fishery. California Fish and Game. 52:240-274.

Cornell Utilities. 2006. Environmental Impact Statement, Lake Source Cooling, Cornell University. Chapter 2.3.6, Zebra and Quagga Mussel Control Measures: Utilities and Energy Management. Cornell University, Ithaca, NY.

Creed, R.T. 1998. A biogeographic perspective on Eurasian watermilfoil declines: additional evidence for the role of herbivorous weevils in promoting declines? Journal of Aquatic Plant Management. 36:16-22.

Doubledee, R., E. Muller, and R. Nisbet. 2003. Bullfrogs, disturbance regimes, and the persistence of California red-legged frogs. Journal of Wildlife Management. 67(2):424-438.

Doyle, R.D. and R.M. Smart. 2001. Effects of drawdown and desiccation on tubers of hydrilla, an exotic aquatic weed. Weed Science. 49:135-140.

Duarte, C.M. and J.Kalff. 1986. Littoral slope as a predictor of the maximum biomass of submersed macrophyte communities. Limnology and Oceanography. 31(5):1072-1080.

Dwyer, W.P., B.L. Kerans, and M.M. Gangloff. 2003. Effect of acute exposure to chlorine, copper, sulfate, and heat on survival of New Zealand mud snails.

Edwards, W.J., C.R. Rehmann, E. McDonald, and D.A. Culver. 2005. The impact of a benthic filter feeder: limitations imposed by physical transport of algae to the benthos. Canadian Journal of Fisheries and Aquatic Sciences 62: 205-214.

Ehler. L.E. 2006. Integrated pest management (IPM): definition, historical development and implementation, and the other IPM. Pest Manage. Sci 62: 787-789.

Flint, R.W. and C.R. Goldman. 1975. The effects of a benthic grazer on the primary productivity of the littoral zone of Lake Tahoe. Limnology and Oceanography 20(6): 935-944.

Frodge, J.D., G.L. Thomas, and G.B. Pauley. 1991. Sediment phosphorus loading beneath dense canopies of aquatic macrophytes. Lake and Reservoir Management 7:61-71.

Fromme, A.E. and M.F. Dybdahl. 2006. Resistance in introduced populations of a freshwater snail to native range parasites. Journal of Evolutionary Biology. 19(6):1948-1955.

Gibbons, M. V., M.G. Rosenkranz, H.L. Gibbons, Jr., and M.D. Sytsma. 1999. Guide for Developing Integrated Aquatic Vegetation Management Plans in Oregon. Center for Lakes and Reservoirs, Portland State University. http://www.clr.pdx.edu/docs/iavmp.pdf

GISD (Global Invasive Species Database). 2008. *Pacifastacus leniusculus* (crustacean). The Global Invasive Species Database. Invasive Species Specialist Group (ISSG) of the IUCN Species Survival Commission. http://www.issg.org/database/welcome/.

Goldman, C. R. 1974. Eutrophication of Lake Tahoe emphasizing water quality. Report EPA–660/3-74-034.

Goldman, C.R., M.D. Morgan, S.T. Threlkeld, and N. Angeli. 1979. A population dynamics analysis of the cladoceran disappearance from Lake Tahoe, California-Nevada. Limnology and Oceanography 24(2): 289-297.

Goldman, C. 1988. Primary production, nutrients, and transparency during the early onset of eutrophication in ultra-oligotrophic Lake Tahoe, California-Nevada. Limnology and Oceanography. 33(6 part 1):1321-1333.

Gottfried, P.K. and J.A. Osburne. 1982. Distribution, abundance and size of *Corbicula manilensis (Philippi)* in a spring-fed central Florida stream. Florida Scientist. 45(3):178-188.

Govindarajulu, P. 2004. Introduced Bullfrogs (*Rana catesbeiana*) in British Columbia: Impacts on Native Pacific Treefrogs (*Hyla regilla*) and Red-Legged Frogs (*Rana aurora*). Ph.D. thesis. University of Victoria, Victoria, BC.

Granéli, W. and D. Solander. 1988. Influence of aquatic macrophytes on phosphorus cycling in lakes. Hydrobiologia. 170(1):245-266.

Hackley, S., B. Allen, G. Schladow, J. Reuter, S. Chandra, and M. Wittmann. 2008. Lake Tahoe Aquatic Invasive Species Incident Report: Notes on visual observations of clams in Lake Tahoe and on the beaches along the southeast shore – Zephyr Cove to Timber Cover Marina: April 25, 2008.

Hagler-Bailly 1999. Chapter 2: Estimates of Total Recreational Watercraft Use For the Lakes of Tahoe: Final Report. Obtained from TERC – Tahoe Environmental Research Center.

Haynes, R. R. 1988. Reproductive biology of selected aquatic plants. Annals of the Missouri Botanical Garden. 75(3):805-810.

Heutte, T., and E. Bella. 2003. Invasive plants and exotic weeds of Southeast Alaska. Anchorage, AK: USDA Forest Service.

Higgins, T.M., J.M. Grennan, and T.K. McCarthy. 2008. Effects of recent zebra mussel invasion on water chemistry and phytoplankton production in a small Irish lake. Aquatic Invasions 3(1): 14-20.

Hudon, C., S. Lalonde, and P. Gagnon. 2000. Ranking the effects of site exposure, plant growth form, water depth, and transparency on aquatic plant biomass. Canadian Journal of Fisheries and Aquatic Sciences. 57(S1):31-42.

ISAC (Invasive Species Advisory Committee). 2006. Invasive species definition clarification and guidance white paper. http://www.invasivespeciesinfo.gov/docs/council/isacdef.pdf. Accessed July 22, 2009.

Jassby, A., C.R. Goldman, J.E. Reuter, and R.C. Richards. 2000. Changes in Water Clarity at Lake Tahoe. UC Davis Tahoe Research Group.

Jassby, A.D., C.R. Goldman, J.E. Reuter, R.C. Richards, and A.C. Heyvaert. 2001. Lake Tahoe: diagnosis and rehabilitation of a large mountain lake. *In*: M. Munawar and R.E. Hecky; (Eds.) The Great Lakes of the World (GLOW): Food-web, Health, and Integrity. Leiden (The Netherlands). Backhuys. 431-454 pp.

Jassby, A.D., J.E. Reuter, and C.R. Goldman. 2003. Determining long-term water quality changes in the presence of climate variability: Lake Tahoe (USA). Canadian Journal of Fisheries and Aquatic Sciences 60:1452-1461.

Johnson, L.E., A. Ricciardi, and J.T. Carlton. 2001. Overland dispersal of aquatic invasive species: a risk assessment of transient recreational boating. Ecological Applications. 11(6):1789-1799.

Kamerath, M., B.C. Allen, and S. Chandra. First documentation of *Salmincola californiensis* in Lake Tahoe, CA-NV, USA. Submitted to Western North American Naturalist February 27, 2008.

Kamerath, M., S. Chandra, and B.C. Allen. 2008. Distribution and impacts of warm water fish in Lake Tahoe, USA. Biological Invasions. 3(1):35-41.

Karatayev, A.Y., L.E. Burlakova, T. Kesterson, and D.K. Padilla, 2003. Dominance of the Asiatic Clam, C*orbicula fluminea* (Muller), in the Benthic Community of a Reservoir, *Journal of Shellfish Research* 22(2): 487-493.

Kay, S.H. and S.T. Hoyle. 2001. Mail, order, the internet, and invasive aquatic weeds. Journal of Aquatic Plant Management. 39(1):88-91.

Kilgour, B.W., and Mackie, G.L. 1993. Colonization of different construction materials by the zebra mussel (*Dreissena polymorpha*). *In:* Zebra mussels: Biology, impacts, and control. T.F. Nalapa and D.W. Schloesser (Eds.). Lewis Publishers. Baco Raton, FL. 167-174 pp.

Kim, J.G. and E. Rejmánková. 2001. The paleolimnological record of human disturbance in wetlands of the Lake Tahoe Basin. Journal of Paleolimnology. 25:437-454.

Leung, B., D.M. Lodge, D. Finoff, J.F. Shrogen, M.A. Lewis, and G. Lamberti. 2002. An ounce of prevention or a pound of cure: bioeconomic risk analysis of invasive species. The Royal Society. 269:2407-2413.

Linn, J.D. and T. C. Frantz. 1965. Introduction of opossum shrimp (*Mysis relicta* Loven) into California and Nevada. California Fish and Game. 51:48-51.

Lodge, D. M., S. Williams, H.J. MacIsaac, K.R. Hayes, B.Leung, S. Reichard, R.N. Mack, P.B. Moyle, M. Smith, D.A. Andow, J.T. Carlton, and A. McMichael. 2006. Biological invasions: recommendations for U.S. policy and management. Ecological Applications. 16(6):2035-2054.

LTAISWG (Lake Tahoe Aquatic Invasive Species Working Group). 2007. Lake Tahoe Aquatic Invasive Species Working Group 2007 Annual Report. www.tahoercd.org/linkeddocs/AISpage/AISpage/2007_annualreport_FINAL.pdf

LRWQCB and NDEP (Lahontan Region Water Quality Control Board and Nevada Department of Environmental Protection). 2007. Draft Lake Tahoe TMDL Technical Report.

MacRae, P. S. D., and D. A. Jackson. 2001. The influence of smallmouth bass (*Micropterus dolomieu*) predation and habitat complexity on the structure of littoral zone fish assemblages. Canadian Journal of Fisheries and Aquatic Sciences 58: 342–351.

Madsen, J. D. 2000. Advantages and disadvantages of aquatic plant management techniques. Rep. ERDC/EL MP-00-01. U.S. Army Corps of Engineers, Vicksburg, MS.

Maguire, C.M. and L.M. Sykes. 2004. Zebra Mussel Management Strategy for Northern Ireland. Queen's University, Belfast, Ireland. 50 pp.

Mangum, F.A. and J.L. Madrigal. 1999. Rotenone effects on aquatic macroinvertebrates of the Strawberry River, Utah: A five-year summary. Journal of Freshwater Ecology 14(1): 125-135.

Maret, T.J., J.D. Snyder, and J.P. Collins. 2006. Altered drying regime controls distribution of endangered salamanders and introduced predators. Biological Conservation 127(2): 129-138.

Mazzei, K.C., R.M. Newman, A. Loos and D.W. Ragsdale. 1999. Developmental rates of the native milfoil weevil, *Euhrychiopis lecontei*, and damage to Eurasian watermilfoil at constant temperatures. Biological Control. 16:139-143.

McMahon, R.F. 1983. Ecology of an invasive pest bivalve, *Corbicula*. *In:* The Mollusca. Vol. 6: Ecology. W.D. Russell-Hunter (Ed.). Academic Press, New York.

Medhurst, R.B. 2003. Presentation of results at the New Zealand Mudsnail Stakeholder Meeting, November 17, 2003, Mammoth Lake, CA (cited in New Zealand Mudsnail Management and Control Plan Working Group [NZMMCPWG] 2007).

Melaas, C.L., K.D. Zimmer, M.G. Butler, and M.A. Hanson. 2001. Effects of rotenone on aquatic invertebrate communities in prairie wetlands. Hydrobiologia 459: 177-186.

Mills, E.L., G. Rosenberg, A.P. Spidle, M. Ludyanskiy, Y. Pligin, and B. May. 1996. A review of the biology and ecology of the Quagga mussel (*Dreissena bugensis*), a second species of freshwater Dreissenid introduced to North America. American Zoologist. 36:271-286.

Molloy, D. 2002. Biological control of zebra mussels. *In*: Proceedings of the Third California Conference on Biological Control. University of California, Davis.

Mullin, B.H., L.W.J. Anderson, J.M. DiTomaso, R.E. Eplee, and K.D. Getsinger. 2000. Invasive Plant Species. Council for Agricultural Science and Technology (CAST), Issue Paper No. 13. 18 pp.

Murphy, D.D. and C.M. Knopp, (Eds.). 2000. Lake Tahoe Watershed Assessment: Volume I. General Technical Report PSW-GTR-175. Albany, CA: Pacific Southwest Research Station, Forest Service, US Department of Agriculture. 753 pp. http://www.treesearch.fs.fed.us/pubs/26709

NANCPA (Nonindigenous Aquatic Nuisance Prevention and Control Act). 1990. http://www.invasivespeciesinfo.gov/laws/publiclaws.shtml#nanpca

Netherland, M.D., J.D. Skogerboe, C.S. Owens, and J.D. Madsen. 2000. Influence of water temperature on the efficacy of diquat and endothall versus curlyleaf pondweed. Journal of Aquatic Plant Management. 38:25-32.

NDOW (Nevada Department of Wildlife). 2008. Nevada Fishing Seasons and Regulations Effective March 1, 2008 – February 28, 2009. 56 pp.

Newman, R.M., K.L. Holmberg, D.D. Biesboer, and B.G. Penner. 1996. Effects of a potential biocontrol agent, *Euhrychiopsis lecontei*, on Eurasian watermilfoil in experimental tanks. Aquatic Botany. 53(3-4):131-150.

Newman, R.M., D.C. Thompson, and D.B. Richman. 1998. Conservation strategies for the biological control of weeds. *In*: P. Barbosa, (Ed.). Conservation Biological Control. Academic Press, New York.

Newman, R.M. and D.D. Biesboer. 2000. A decline of Eurasian watermilfoil in Minnesota associated with the milfoil weevil, *Euhrychiopsis lecontei*. Journal of Aquatic Plant Management. 38:105-111.

NISC (National Invasive Species Council). 2008. 2008-2012 National Invasive Species Management Plan. National Invasive Species Council, Department of the Interior, Washington, DC. http://www.invasivespeciesinfo.gov/council/mp2008.pdf

NZMMCPWG (New Zealand Mudsnail Management and Control Plan Working Group). 2007. National Management and Control Plan for the New Zealand mudsnail (*Potamopyrgus antipodarum*). Aquatic Nuisance Species Task Force.

Padilla, D.K., M.A. Chotkowski, and L.A.J. Buchan. 1996. Predicting the spread of zebra mussels (*Dreissena polymorpha*) to inland waters using boater movement. Global Ecology and Biogeography Letters. 5(6):353-359.

Pauli, B., D. Coulson, and M. Berrill. 1999. Sensitivity of amphibian embryos and tadpoles to mimic ((R)) 240 LV insecticide following single or double exposures. Environmental Toxicology and Chemistry. 18(11):2538-2544.

Raumann, C.G. and M.E. Cablk. 2008. Change in the forested and developed landscape of the Lake Tahoe Basin, California and Nevada, USA, 1940-2002. Forest Ecology and Management 255(8-9): 3424-3439.

Richards, R.C., C.R. Goldman, T.C. Franz, and R. Wickwire. 1975. Where have all the Daphnia gone? The decline of major cladoceran in Lake Tahoe, California-Nevada. Verhandlungen International Verein, Limnologie. 19:835-842.

Reuter, J.E., and W.W. Miller. 2000. Aquatic resources, water quality and limnology of Lake Tahoe and its upland watershed Ch. 4: 150-166, In Lake Tahoe Watershed Assessment. Department of the Interior, US

Schwarz, A.M. and C. Howard-Williams. 2000. Analysis of relationships between maximum depth limits of aquatic plants and underwater light in 63 New Zealand lakes. New Zealand Journal of Marine and Freshwater Research. 34:157-174.

Shaw, T. 2004. Zebra Mussels (*Dreissena polymorpha*) in the Chesapeake Bay Watershed: A Regional Management Plan (Final Draft). The Regional *Dreissena polymorpha* Working Group, The Pennsylvania Department of Environmental Protection, Harrisburg, PA. 33 pp.

Sheldon, R. B. and Charles W. Boylen. 1977. Maximum depth inhabited by aquatic vascular plants. The American Midland Naturalist. 97(1):248-254.

Smith, C. S. and J.W. Barko. 1990. Ecology of Eurasian watermilfoil. Journal of Aquatic Plant Management. 28:55-64.

Spencer, D. F. and G.G. Ksander. 2004. Do tissue carbon and nitrogen limit population growth of weevils introduced to control water hyacinth at a site in the Sacramento-San Joaquin Delta, California? Journal of Aquatic Plant Management. 42:45-48.

Stites, D.L., A.C. Benke, and D.M. Gillespie. 1995. Population dynamics, growth, and production of the asiatic clam, *Corbicula fluminea* in a Blackwater River. Canadian Journal of Fisheries and Aquatic Sciences. 52:425-437.

TERC (Tahoe Environmental Research Center). 2008. State of the Lake Report 2008. http://169.237.166.248/stateofthelake/StateOfTheLake2008.pdf

TRPA (Tahoe Regional Planning Agency). 2008. Proposed Regional Plan and Environmental Threshold Carrying Capacities Update: Draft Executive Summary of Concepts Contained in Alternative #2. http://www.trpa.org/documents/RP_Exec_Summary_4-09-08.pdf.

Tuchman, N.C., R.L. Burks, C.A. Call, and J. Smarrelli. 2004. Flow rate and vertical position influence ingestion rates of colonial zebra mussels (*Dreissena polymorpha*). Freshwater Biology 49: 191-198.

USACE (U.S. Army Corps of Engineers). 2009. Zebra Mussel Information System. http://el.erdc.usace.army.mil/zebra/zmis/zmishelp.htm. Accessed June 23, 2009.

UCD (University of California - Davis) (2008, March 26). Global Warming Could Radically Change Lake Tahoe In Ten Years. Science Daily. Accessed 15 May 2008. http://www.sciencedaily.com /releases/2008/03/080325141202.htm

USDA (U.S. Department of Agriculture). 2000. Lake Tahoe Watershed Assessment. Vol. 1. Pacific Southwest Research Station.

USFWS (U.S. Fish and Wildlife Service). 1995. Recovery Plan for the Lahontan Cutthroat Trout. USFW Region 1, Portland, Oregon, 90 pp.

USGS (U.S. Geological Survey). 2008. Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/. Accessed 23 April 2008

Vander Zanden., M.J., S. Chandra, B.C. Allen, J.E. Reuter, and C.R. Goldman. 2003. Historical food web structure and restoration of native aquatic communities in the Lake Tahoe (California-Nevada) Basin. Ecosystems. 6:274-288.

Walter, K.M., L.W. Anderson, and C.R. Goldman. 2000. Assessing potential for spread and impacts of Eurasian watermilfoil (*Myriophyllum spicatum*) in Lake Tahoe using *in situ* transplants, microcosms, and bioassays. http://trg.ucdavis.edu/research/annualreport/contents/lake/article10.html

Washington Department of Ecology. 2008. Aquatic Plant Management. http://www.ecy.wa.gov/programs/wq/plants/management/. Accessed 7 May 2008.

Wittmann, M. 2008. Recreational Boating and the Spread of Aquatic Invasive Species in and Around Lake Tahoe, California-Nevada. Ph.D. Thesis. University of California Santa Barbara.

Wittmann, M., S. Chandra, J. Reuter, and G. Schladow. 2008. Asian clam and Lake Tahoe: Preliminary Findings and Future Needs. Technical Report. University of California Davis, TERC and University of Nevada Reno.

Wright, P. 1996. Nitrogen metabolism and excretion in bullfrog (*Rana catesbeiana*) tadpoles and adults exposed to elevated environmental ammonia levels. Physiological Zoology. 69(5):1057-1078.

WRP (Western Regional Panel). 2003. Model Rapid Response Plan for Aquatic Nuisance Species. http://www.fws.gov/answest/Docs/WRP%20RRP%20Final,%20Part%20II.pdf

WRP (Western Regional Panel). 2009. Quagga-Zebra Mussel Action Plan for Western U.S. Waters. Submitted to the Aquatic Nuisance Species Task Force May 2009.

Appendices

Lake Tahoe Region
Aquatic Invasive Species Management Plan
CALIFORNIA - NEVADA

Appendix A: Regulations and Programs

1 Existing Authorities and Programs

The Lake Tahoe Basin is located on the California-Nevada border and crosses three counties in California (CA) and two counties and Rural Carson City in Nevada (NV). The majority of the land in the Basin is owned and managed by public agencies (e.g., USFS-LTBMU, California Department of Parks and Recreation, Nevada Division of State Parks, and the California Tahoe Conservancy). Most of the private lands are commercial and residential development located in the low lying areas near the lake.

Numerous aquatic invasive species (AIS) are established in or threatening introduction to aquatic ecosystems throughout California and are addressed in the CA AIS Management Plan. The State of Nevada does not currently have an AIS management plan or a well-coordinated AIS program. Instead, the state must rely on the disparate efforts of regional, state, and federal agencies.

The following summarizes federal, state, and regional regulations and programs pertinent to AIS issues in the Lake Tahoe Basin. Information sources included the Tahoe Integrated Information Management System (TIIMS), the California AIS Management Plan, and stakeholder input (Appendix D).

FEDERAL

Endangered Species Act (ESA) of 1973
(16 U.S.C.A. §§ 1531 to 1544)

http://www.fws.gov/endangered/

The ESA is jointly administered by the USFWS and NMFS, and allows them to "use all methods and procedures which are necessary to bring any endangered or threatened species to the point at which the measures provide pursuant to this Act are no longer necessary." Listed species in Lake Tahoe are all freshwater species and are therefore under the jurisdiction of the USFWS (NMFS regulates anadromous and marine species). The purpose of the ESA is to provide the means to identify and protect species that are in danger of significant population loss or extinction and to conserve the ecosystems upon which endangered and threatened species depend. . Relevant permits (e.g. USFWS ESA Section 7 consultation) will be obtained prior to commencing potentially harmful management actions.

Executive Order (EO) 13057 (7/26/97)

http://www.epa.gov/region09/water/watershed/1997-2007-fip-report.pdf

Under EO 13057, federal agencies with responsibilities at Lake Tahoe are directed to form the Lake Tahoe Federal Interagency Partnership. The purpose of the Partnership is to coordinate federal, tribe, state, regional (i.e. Tahoe Regional Planning Agency), and local government activities in the Basin to improve environmental efforts. The Partnership consults with the Lake Tahoe Basin Federal Advisory Committee (LTFAC) to ensure diverse input from a range of stakeholders on issues critical to the Basin and facilitates the integration and coordination of appropriate federal programs and funds to help achieve the goals of the Lake Tahoe Regional Environmental Improvement Program (EIP).

Executive Order (EO) 13112 (64 FR 6183, 2/3/99)

EO 13112 established the National Invasive Species Council (NISC) tasked with preparing a National Invasive Species Management Plan to ensure that Federal agency activities are "coordinated, complementary, cost-efficient, and effective" in their efforts to address invasive species issues. The 2008-2012 NISP was released August 2008 and is available at http://www.invasivespeciesinfo.gov/council/mp2008.pdf. The Order also calls for Federal agencies "whose actions may affect the status of invasive species…to identify such actions [and] use relevant programs and authorities to detect and respond rapidly to and control populations in a cost-effective and environmentally sound manner." The USEPA provides an overview of authorities affected by the development of rapid response plans for AIS (USEPA 2005): http://www.epa.gov/owow/invasive_species/invasives_management/).

Injurious Wildlife Provisions of the Lacey Act (18 USC 42; 50 CFR 16)

http://www.fws.gov/contaminants/ANS/ANSInjurious.cfm
http://www.fws.gov/laws/lawsdigest/lacey.html

The Service has broad authority to detain and inspect any international shipment, mail parcel, vehicle, or passenger baggage and all accompanying documents, whether or not wildlife has been formally declared. The injurious wildlife provision of the Lacey Act is one tool that the U.S. Fish and Wildlife Service uses to prevent illegal introductions of and to manage invasive species. Under the Lacey Act, importation and interstate transport of animal species determined to be injurious may be regulated by the Secretary of the Interior. The Service implements the injurious wildlife provisions (18 U.S.C. 42) through regulations contained in 50 CFR Part 16. Species are added to the list of injurious wildlife to prevent their introduction or establishment through human movement in the United States to protect the health and welfare of humans, the interests of agriculture, horticulture or forestry, and the welfare and survival of wildlife resources from potential and actual negative impacts.

Species listed as injurious may not be imported or transported between States, the District of Columbia, the Commonwealth of Puerto Rico, or any territory or possession of the U.S. by any means without a permit issued by the Service. Permits may be granted for the importation or transportation of live specimens of injurious wildlife and their offspring or eggs for bona fide scientific, medical, educational, or zoological purposes. This section of the Lacey Act also regulates that health certificates must accompany all imports of fresh or frozen fish produced commercially and salmon and trout harvested recreationally outside North American waters. Live salmon eggs also require health certificates.

The penalty for an injurious wildlife Lacey Act violation is up to six months in prison and a $5,000 fine for an individual or a $10,000 fine for an organization. Another section of the Lacey Act (16 U.S.C. 3371-3378) pertains to prohibited acts for wildlife and plants; this is different from the injurious wildlife provisions of the Lacey Act, though an enforcement relationship between the two does exist. Please see http://www.fws.gov/le/LawsTreaties/USStatute.htm for more information.

The current federal list of injurious wildlife species (50 CFR 16.11-16.15) may be found at http://www.gpoaccess.gov/cfr/index.html and do a "Quick Search" for "50CFR16".

Lake Tahoe Federal Advisory Committee (LTFAC)
(5 U.S.C. App. 7/17/98)

http://www.fs.fed.us/r5/ltbmu/local/ltfac/

The LTFAC was chartered under the Federal Advisory Committee Act by the Secretary of Agriculture. This citizen committee is concerned with environmental and economic issues in the Lake Tahoe Region. The LTFAC provides guidance to the Secretary of Agriculture and, according to Executive Order 13057, the Federal Interagency Partnership to achieve the goals outlined in the Lake Tahoe Regional Environmental Improvement Program (EIP).

Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) and National Invasives Species Act of 1996 (NISA)

The NANPCA (P.L. 101-636) establishes federal authority to prevent the introduction of nuisance aquatic organisms and control their spread through coordinated research, control strategies, priorities, and education efforts. The Act mandates that the Aquatic Nuisance Species Task Force (ANSTF) implement the NANPCA. In 1996 NANPCA was amended by NISA to require ballast water exchanges for vessels entering the Great Lakes and Hudson River. NISA also establishes guidelines for vessels entering U.S. waters from outside the exclusive economic zone (EEZ) to voluntarily exchange ballast.

Under Section 1204, the Act calls on states to develop comprehensive management plans to coordinate efforts aimed at preventing and controlling nuisance species through technical, enforcement, or financial assistance as needed. Section 1204 also allows for federal contributions up to 75 percent of the cost incurred by states each fiscal year for implementing AIS plans.

The ANSTF is an intergovernmental organization responsible for implementing mandates under the NANPCA. The goals of the Task Force are to 1) reduce AIS introduction, 2) minimize their effects, 3) increase public awareness, and 4) maximize ANSTF effectiveness (ANSTF 2007). The ANSTF provides guidance for writing state and interstate management plans as outlined in their *Guidance for State and Interstate Aquatic Nuisance Species Managements Plans* and has established formal review and submission processes leading to plan approval and Section 1204 support. Other western states with approved management plans include Oregon, Washington, Idaho, and Montana. Western states with plans in development include Arizona, Utah, New Mexico, Colorado, and Wyoming. The *Lake Champlain Basin ANS Management Plan* and *St. Croix Natural Scenic Riverway Interstate Management Plan* are the only other regional management plans.

National Environmental Policy Act of 1970
(NEPA; 42 U.S.C.A. §§ 4321 to 4370e)
http://www.epa.gov/compliance/nepa/index.html
NEPA requires the consideration of environmental impacts for any federal action, including direct federal activities, permitting and federal funding of activities by another entity. NEPA environmental documents may include an environmental assessment (EA), or a full environmental impact statement (EIS). Potential impacts of invasive species, both direct and indirect, may be among the issues that should be considered under NEPA.

U.S. Army Corps of Engineers (USACE)
http://www.spk.usace.army.mil
The United States Army Corps of Engineers (USACE) serves the Armed Forces and the Nation by providing vital engineering services and capabilities through planning, design, and construction for the nation's water resources, environmental restoration, infrastructure, Homeland Security, and military needs.

In the Tahoe Basin, the USACE provides program and project level technical assistance to non-federal agencies in implementation of authorized programs including stream and wetland restoration, storm water management and treatment effectiveness, shorezone sanitary sewer line replacement, water quality assessment, and management of aquatic invasive species. Additionally, USACE has responsibility for CWA Section 404 permitting and Section 10 navigation hazards permitting. Any management activities that may affect wetlands or other jurisdictional waters, or which may affect navigation, will require consultation with the USACE.

U.S. Department of Agriculture (USDA)
www.usda.gov/
The mission of the USDA is to provide leadership on food, agriculture, natural resources, rural development, and related issues based on sound public policy, the best available science, and efficient management (USDA Strategic Plan FY 2005-2010). The USDA is part of the executive branch of the Federal Government with 17 agencies associated with specific mission areas. Those agencies with mission areas related to AIS in the Tahoe Basin include:

> USDA-Animal and Plant Health Inspection Service (APHIS): responsible for protecting and promoting US agricultural health. http://www.aphis.usda.gov/
>
> USDA-APHIS-Plant Protection and Quarantine (PPQ): enforces Federal Noxious Weed regulations (Plant Protection Act of 2000, Subtitle A. section 412) prohibiting the import into the U.S. and/or interstate movement of federal noxious weeds (7 CFR 319.37 -2). www.aphis.usda.gov/ppq
>
> USDA – Agricultural Research Service (USDA-ARS): conducts scientific research on agricultural problems including food safety, nutrition, economics, and the environment. At Lake Tahoe, USDA-ARS has monitored the introduction and spread of Eurasian watermilfoil and curlyleaf pondweeds since 1996. http://www.aphis.usda.gov/
>
> USDA-Natural Resources Conservation Service (NRCS): provides leadership in a partnership effort to help people conserve, improve, and sustain our natural

resources and environment. In partnership with the NRCS National Information Technology Center (NITC), the National Plant Data Center (NPDS) maintains the online PLANTS Database. The searchable database provides plant descriptions, distribution maps, references, plant abstracts, and plant images http://plants.usda.gov.

USDA-National Agricultural Library (NAL): provides a comprehensive list of federal laws and regulations associated with invasive species, including freshwater, marine, and terrestrial organisms through the website: http://www.invasivespeciesinfo.gov/laws/publiclaws.shtml

USDA can restrict the introduction and spread of noxious weeds (under the Plant Protection Act (PPA) 7 U.S.C; 6/20/00; noxious weed defined in the Sec. 403 PPA 7 U.S.C. 7702(10)) and regulated pests (7 CFR 300-399). The Noxious Weed Control and Eradication Act (P.L. 108-412; 10/30/04) established a program to provide financial and technical assistance to control or eradicate noxious weeds. The Act allows for grants (section 454) to control or eradicate noxious weeds, subject to availability of appropriations under section 457(b). http://www.invasivespeciesinfo.gov/laws/publiclaws.shtml

USDA – U.S. Forest Service (USFS): The mission of the USFS is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations.

USDA-USFS-Lake Tahoe Basin Management Unit (LTBMU): The LTBMU manages 80% of the land in the Lake Tahoe Basin as a unique kind of national forest. The LTBMU is managed in many ways like other national forests, but because of the needs of the lake and the relationship it has with the forests that surround it, the LTBMU has special focus areas, including watershed restoration.

The National Forest Land Management Act (NFMA) directs Forest Service units to draft and implement Land and Resource Management Plans. The LTBMU's "Forest Plan" is the road map that guides multiple use management and sets direction for accomplishing aquatic ecosystems goals and objectives, which includes AIS considerations.

LTBMU aquatic biologists are engaged in a number of AIS management functions including: prevention, treatment and research. The LTBMU manages a variety of recreation sites that provide the public both direct (i.e. boat launches) and indirect (i.e. campgrounds) access to Lake Tahoe and other waterbodies. LTBMU aquatic program staff are engaged in AIS prevention strategies at recreation facilities. In addition, LTBMU aquatic biologists have taken a leadership role in restoring aquatic habitat for native species by removing and/or controlling aquatic invasive species. http://www.fs.fed.us/r5/ltbmu/

U.S. Department of Interior (USDOI)

http://www.doi.gov/

The USDOI is the nation's principal conservation agency responsible for natural resources, natural and cultural heritage access, recreation, scientific research, energy and mineral resources, land and water resources, and fish and wildlife. The USDOI is comprised of eight bureaus with specific mission areas. Those bureaus with mission areas related to AIS in the Tahoe Basin include:

> Bureau of Land Management (BLM): the BLM manages 264 million acres of surface acres of public lands located primarily in the 12 Western States, including Alaska. The agency manages an additional 300 million acres of below ground mineral estate located throughout the country. Originally, these lands were valued principally for the commodities extracted from them; today, the public also prizes them for their recreational opportunities and their natural, historical, and cultural resources they contain.
>
> Under the Southern Nevada Public Land Management Act (SNPLMA), the BLM is allowed to sell public land within a specific boundary around Las Vegas, Nevada. The revenue derived from land sales is split between the State of Nevada General Education Fund (5%), the Southern Nevada Water Authority (10%), and a special account available to the Secretary of the Interior for Lake Tahoe restoration projects, among other conservation efforts. In the Tahoe Basin, SNPLMA funds have been used to support numerous AIS-related projects (see Appendix E Potential Economic Impacts).
>
> USDOI - U.S. Bureau of Reclamation (USBOR): The mission of the USBOR is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.
>
> USDOI - U.S. Fish and Wildlife Service (USFWS): The mission of the USFWS is to work with others to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. Nationally, the USFWS has partnered with several agencies and organizations to provide widely recognized education/outreach information and downloadable materials, including: The 100th Meridian Initiative (http://www.100thmeridian.org/), the Stop Aquatic Hitchhikers Campaign (www.protectyourwaters.com), and HabitattitudeTM (www.habitattitude.net).
>
> USDOI - U.S. Geological Survey (USGS) – Nuisance Aquatic Species (USGS-NAS): The USGS-NAS website (http://nas.er.usgs.gov/) serves as a “central repository for accurate and spatially referenced biogeographic accounts of nonindigenous aquatic species”, including freshwater and marine fishes, invertebrates, and plants. The website is managed from the USGS Florida Integrated Science Center (FISC).

STATE AND REGIONAL

California Department of Parks and Recreation (CADPR)

www.parks.ca.gov

The mission of the CADPR is: to provide for the health, inspiration and education of the people of California by helping to preserve the state´s extraordinary biological diversity, protecting its most valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation. The CADPR is a TIIMS stakeholder that participated in the requirements analysis. CADPR is responsible for overseeing State Park lands that lie within the California side of the Lake Tahoe Basin. As such, they maintain the lands and provide educational information to park visitors. Specifically, they oversee the following park units: Burton Creek State Park, D. L. Bliss State Park, Ed Z'berg Sugar Pine Point State Park, Emerald Bay State Park, Kings Beach State Recreation Area, Lake Valley State Recreation Area, Tahoe State Recreation Area, Ward Creek Unit, and Washoe Meadows State Park.

California-Nevada Compact for Jurisdiction on Interstate Waters

California Penal Code Section 853.3-853.4 (see below) essentially allows California and Nevada law enforcement agents to enforce "like" laws. For example, because mussels are a prohibited species in Nevada (NAC 503 §110) and California (California Code Regulations Title 14 §671), NDOW Game Wardens may stop and detain watercraft with visible (not suspected) mussels if the vessel is on Lake Tahoe. If the vessel is contaminated, then Nevada law would be enforced.

> 853.3. (a) Pursuant to the authority vested in this state by Section 112 of Title 4 of the United States Code, the Legislature of the State of California hereby ratifies the California-Nevada Compact for Jurisdiction on Interstate Waters as set forth in Section 853.4.
>
> (b) The Legislature finds that law enforcement has been impaired in sections of Lake Tahoe and Topaz Lake forming an interstate boundary between California and Nevada because of difficulty in determining precisely where a criminal act was committed.
>
> (c) The Legislature intends that a person arrested for an act that is illegal in both states should not be freed merely because neither state could establish that a crime was committed within its boundaries.
>
> (d) The California-Nevada Compact for Jurisdiction on Interstate Waters is enacted to provide for the enforcement of the laws of this state with regard to certain acts committed on Lake Tahoe or Topaz Lake, on either side of the boundary line between California and Nevada.
>
> 853.4. (a) As used in this compact, unless the context otherwise requires, "party state" means a state that has enacted this compact.
>
> (b) If conduct is prohibited by the party states, courts and law enforcement officers in either state who have jurisdiction over criminal offenses committed in a county where Lake Tahoe or Topaz Lake forms a common interstate boundary have concurrent jurisdiction to arrest, prosecute, and try offenders for the

prohibited conduct committed anywhere on the body of water forming a boundary between the two states.

(c) This section applies only to those crimes that are established in common between the States of Nevada and California, and an acquittal or conviction and sentence by one state shall bar a prosecution for the same act or omission by the other.

(d) This compact does not authorize any conduct prohibited by a party state.

(e) This compact shall become operative when ratified by law by the party states and shall remain in full force and effect so long as the provisions of this compact, as ratified by the State of Nevada, remain substantively the same as the provisions of this compact, as ratified by this section. This compact may be amended in the same manner as is required for it to become operative.

California Department of Food and Agriculture (CDFA)

www.cdfa.ca.gov/regulations.html

CDFA is the lead agency for regulatory activities associated with aquatic weeds. This regulatory authority includes quarantine, exterior pest exclusion (border protection stations and inspections), interior pest exclusion (pet/aquaria stores, aquatic plant dealers and nurseries) and detection and control/eradication programs. In addition, the CDFA Plant Pest Diagnostic Center identifies plant species and assigns plant pest ratings. CDFA maintains a rated list of noxious weed species.

"A"-rated pests require eradication, containment, rejection or other holding actions at the state-county level. Quarantine interceptions are to be rejected or treated at any point in the state. For "B"-rated pests, eradication, containment, control or other holding actions are taken at the discretion of the agricultural commissioner. State-endorsed holding actions and eradication of "C"-rated pests occur only when these pests are found in a nursery. Action is taken to retard spread outside of nurseries at the discretion of the commissioner. Rejection occurs only when found in a crop seed for planting or at the discretion of the commissioner. "Q" ratings are temporary "A" ratings pending determination of a permanent rating.

California Department of Fish and Game (CDFG)

http://www.dfg.ca.gov/invasives/

http://www.fgc.ca.gov/html/regs.html

http://www.dfg.ca.gov/ospr/organizational/scientific/exotic/exotic%20report.htm

The CDFG maintains native fish, wildlife, plant species and natural communities for their intrinsic and ecological value and their benefits to people. This includes habitat protection and maintenance in a sufficient amount and quality to ensure the survival of all species and natural communities. The department is also responsible for the diversified use of fish and wildlife including recreational, commercial, scientific and educational uses.

The CAISMP was directed by the CDFG to "coordinate state programs, create a statewide decision-making structure and provide a shared baseline of data and agreed-upon actions so that state agencies may work together more efficiently".[Error! Bookmark not defined.]

The CDFG sees the implementation of Fish and Game Codes related to fish and wildlife resources. According to Title 14 of the California Code of Regulations, CDFG is responsible for the following Fish and Game Codes as related to AIS (adapted from the CAISMP:

F& G Code §§ 2080 – 2089: CDFG regulates the take of species listed under the California Endangered Species Act. In addition to the instructions in the Fish and Game Code, guidelines for this process are located in Title 14, Division 1, Subdivision 3, Chapter 6, Article 1 of the California Code of Regulations. These statutes and regulations should be consulted if AIS control measures have the potential to impact State-listed species.

F & G Code §§ 2118, 2270-2300: CDFG is responsible for enforcement of importation, transportation and sheltering of restricted live wild animals; places importation restrictions on aquatic plants and animals.

F & G Code §§ 2301: Allows staff to inspect, impound or quarantine any conveyance (e.g. watercraft) that may carry dreissenid mussels and (by delegation) allows other state agencies (e.g. California Department of Parks and Recreation) to enforce the code.

F & G Code §§ 2302: Owners of publicly accessible reservoirs (as defined in Section 6004.5 of the California Water Code) where recreational activities are permitted are required to assess its vulnerability dreissenid mussel introduction, develop and implement a dreissenid mussel prevention program. Owners may refuse planting of fish unless CDFG demonstrates they are not infected with dreissenid mussels.

F & G Code §§6400-6403: It is unlawful to place live fish, fresh or saltwater animals or aquatic plants in any waters of this state without a permit from CDFG.

F & G Code §§15000 et seq.: CDFG is responsible for regulations pertaining to the aquaculture industry, including disease issues.

California Environmental Quality Act (CEQA)
(CA Public Resources Code §§ 21000 et seq.)
http://ceres.ca.gov/ceqa/

The CEQA requires public disclosure of all significant environmental effects of proposed discretionary projects. This process occurs through preparation and distribution of an Initial Study (IS) or an Environmental Impact Report (EIR). If a project would cause significant effects, final documents in the CEQA process show: 1) what mitigation measures will be required to reduce particular effects to a less significant level; and 2) provide justifications for the approval of the project with particular significant effects left unmitigated (i.e. a finding of overriding consideration). CEQA also contains lists of project types exempt from this process. A "significant" impact is a "substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project including land, air, water, minerals, flora, [and] fauna . . .”. The documented adverse impacts associated with invasive species can fit this broad definition.

California State Lands Commission (CSLC)

http://www.slc.ca.gov/

The State of California acquired sovereign ownership of all tide and submerged lands and beds of navigable waterways upon its admission to the United States in 1850. The State holds these lands for the benefit of all people of the State for statewide Public Trust purposes, which include waterborne commerce, navigation, fisheries, water-related recreation, habitat preservation and open space. The boundaries of these State-owned lands generally are based upon the last naturally occurring location of the ordinary high or low water marks prior to artificial influences, which may have altered or modified the river or shoreline characteristics. On navigable non-tidal waterways, the State holds fee ownership of the bed of the waterway landward to the ordinary low water mark and a Public Trust easement exists landward to the ordinary high water mark, as they last naturally existed. The State's sovereign interests are under the jurisdiction of the California State Lands Commission (CSLC).

With respect to Lake Tahoe, the State’s sovereign ownership extends waterward from the low water mark, which has been established as elevation 6,223 feet, Lake Tahoe Datum (LTD). Consequently, any activity involving the State’s sovereign lands in Lake Tahoe below elevation 6,223’ LTD requires a lease from the CSLC. Uses requiring approval of a lease from the CSLC must also comply with the California Environmental Quality Act (CEQA). The area lying between the high and low marks of Lake Tahoe is subject to a Public Trust easement for commerce, navigation, fishing, recreation and preservation. Uses situated between the high and low water marks must be consistent with the uses permitted under the Public Trust.

Permission from the CSLC would be required to implement the proposed activities contemplated by resource managers and researchers. The form of that permission would vary in accordance with the specific activity and its location and, therefore, would be determined on a case-by-case basis.

California Tahoe Conservancy (CTC)

http://www.tahoecons.ca.gov/

The Conservancy is an independent State agency within the Resources Agency of the State of California. It was established to develop and implement programs through acquisition and site improvement to improve water quality in Lake Tahoe, preserve the scenic beauty and recreational opportunities of the region, provide public access, preserve wildlife habitat areas, and manage and restore lands to protect the natural environment.

Environmental Improvement Program (EIP)

http://www.trpa.org/default.aspx?tabid=227

The EIP was first envisioned at the 1997 Presidential Summit at Lake Tahoe. The EIP is a collaborative effort to preserve, restore, and enhance the environment and water clarity of Lake Tahoe. The program provides $900 million over a 10 year period to restore the Lake Tahoe Basin by 1) designating federal lands in the Basin as National Scenic Forest and Recreation Areas, 2) providing $200 million to the USFS to develop, prioritize and implement environmental restoration projects, and 3) providing $100 million over 10 years to control erosion on federal lands.

Funds for the EIP are provided by the states of California and Nevada, as well as local, regional and federal sources. Federal contribution to the EIP is authorized by the Lake Tahoe Restoration Act (PL 106-506; 11/13/00) (LTRA) which allows the federal government to invest $300 million a year for 10 years. Funds for the federal contribution are provided from the Southern Nevada Public Land Management Act (SNPLMA). Enacted in 1998, SNPLMA allows the US Department of Interior Bureau of Land Management (BLM) to sell surplus public land near Las Vegas, NV to support environmental and capital improvement projects. In November 2003, SNPLMA was amended (P.L. 108-108) to direct the authorized $300 million over eight years to support the federal share of EIP projects. To date, the EIP has invested $1.1 billion dollars in capital improvement, research, program support, and operation and maintenance projects in the Tahoe Basin. As much as 50% has been invested in water quality projects. No funds were specifically allocated for aquatic invasive species management in the EIP. In August 2008, Secretary of the Interior Dirk Kempthorne approved $54 million for Lake Tahoe projects, $24 million for Lake Tahoe restoration projects and $30 million to the EIP.

Lahontan Regional Water Quality Control Board (LRWQCB)
http://www.swrcb.ca.gov/rwqcb6/
The State Water Resources Control Board along with nine Regional Boards were established (according to drainage basins) under the Porter-Cologne Water Quality Act. The State Water Quality Control Board and regional boards are responsible for implementing the Clean Water Act in California. The mission of the LRWQCB is to develop and enforce water quality objectives and implementation plans which will best protect the beneficial uses of the State's waters, recognizing local differences in climate, topography, geology and hydrology. The LRWQCB works to preserve and enhance the quality of California's water resources and ensure their proper allocation and efficient use for the benefit of present and future generations.

Regional Boards are directed to develop basin plans. In the Tahoe Region, the Water Quality Control Plan for the Lahontan Region (Basin Plan) is the guiding document for water quality objectives and implementation measures (LRWQCB 1995). With respect to managing AIS, the Basin Plan states that regionwide water quality objectives for pesticides, and related objectives for nondegradation and toxicity, essentially preclude direct discharges of pesticides such as aquatic herbicides. The Lahontan Regional Board's regionwide control measures for pesticides (as defined by CA Agriculture Code § 12753), discussed in Chapter 4 of the Basin Plan, are applicable in the Lake Tahoe Basin.

Since some strategies to control AIS may likely involve chemical controls, the Water Board will likely initiate a Basin Plan amendment process to allow for such application when appropriate. The Basin Plan outlines procedures for the Lahontan Water Board staff to bring a proposal to the Regional Water Board for amending the Basin Plan to allow the use of pesticides for treatment of AIS. Page 5-6 of the Basin Plan sets forth the following amendment procedures:

"… the Lahontan Regional Board sets priorities for Basin Plan revisions as part of its Triennial Review process. The Regional Board may also initiate Basin Plan amendments at any time in response to other issues of concern. As more information becomes available about the water quality and beneficial uses of waters of the Lake Tahoe HU, the Regional Board may consider changes in water quality standards such as adoption of numerical objectives for tributary streams which do not currently have them. The control measures set forth in this Chapter have been determined to be the **minimum** needed to prevent further degradation of Lake Tahoe due to sediment and nutrient loading, and to ensure eventual attainment of clarity and productivity standards. Additional controls on sediment and nutrient loading may need to be developed in the future to offset the impacts of unforeseen factors such as the mortality of forest trees due to drought-related stresses in the late 1980s and early 1990s. Additional control measures may also need to be developed to ensure attainment of the standards contained in the USEPA's National Toxics Rule. Any substantial future changes in provisions of the TRPA 208 Plan which have been incorporated into this Lahontan Basin Plan may trigger consideration of corresponding Basin Plan amendments.

Before they take effect, Basin Plan amendments adopted by the Regional Board must be approved by the State Board and the California Office of Administrative Law. Amendments requiring scientific justification must undergo scientific peer review."

Lake Tahoe AIS Coordination Committee (LTAISCC)

The LTAISCC is comprised of state and federal agency representatives, researchers, and other groups responsible for management, regulatory, or cultural heritage activities in the Basin. Formed in late-2007, the Committee's first task is to provide "high level leadership and direction to the implementation" of the Plan and the Lake Tahoe AIS Working Group (LTAISWG) (Zach Hymanson, TSC personal communication). Committee members are tasked with ensuring that activities proposed by the Plan are either consistent with current agency policy or working in-house to "expand or modify policies and management strategies as a means to expanding the tools available in the *Lake Tahoe Basin Aquatic Invasive Species Management Plan*" (Hymanson personal communication).

Lake Tahoe AIS Working Group (LTAISWG)

http://www.tahoercd.org/AquaticInvasives.php

The LTAISWG is a diverse stakeholder group comprised of state and federal agency representatives, local community members, and researchers that resulted from a stakeholder workshop in 2007 and now has 10 partners per a 2007 Memorandum of Understanding (MOU) (Appendix D, Attachment A). The mission of the LTAISWG to protect the Lake Tahoe Basin from aquatic invasive species by education, research, prevention, early detection, rapid response, and control. Through quarterly meetings and a website, the Working Group has successfully facilitated the coordination of numerous prevention and management efforts in the Basin.

Existing LTAISWG subcommittees include: Education and Outreach, the Tahoe Keys Integrated Warm Water Fish & Aquatic Weed Project, and the Asian Clam Monitoring and Removal Project. Additional subcommittees are created on an as needed basis.

League to Save Lake Tahoe

http://www.keeptahoeblue.org

Started in 1957, the League to Save Lake Tahoe is dedicated to protecting and restoring the environmental quality, scenic beauty, and low-impact recreational opportunities of the Lake Tahoe Basin. We focus on water quality, its clarity, and other critical environmental issues to "Keep Tahoe Blue."

Nevada Department of Environmental Quality (NDEP) - Bureau of Safe Drinking Water

http://ndep.nv.gov/bsdw/index.htm

The mission of the Bureau of Safe Drinking Water is to protect the public health of the citizens, tourists and visitors to the State by assuring that the public water systems provide safe and reliable drinking water. Nevada Revised Statute 445A.800 states, "It is the policy of this state to provide for water which is suited for drinking and other domestic purposes and thereby promote the public health and welfare." With respect to AIS, control activities in and around water intakes that involve physical removal processes (e.g., that could disturb sediment and increase turbidity) or the application of pesticides can have an impact on compliance with regulations and serving potable water.

The Nevada Department of Wildlife (NDOW)

www.ndow.org/fish/exotic/

http://www.ndow.org/law/regs/index.shtm#boat

The NDOW is the state agency responsible for the restoration and management of fish and wildlife resources, and the promotion of boating safety on Nevada's waters. NDOW's mission is to protect, preserve, manage and restore wildlife and its habitat for their aesthetic, scientific, educational, recreational, and economic benefits to citizens of Nevada and the United States, and to promote the safety of persons using vessels on the waters of Nevada.

NDOW is primarily funded by sportsmen's license and conservation fees and a federal surcharge on hunting and fishing gear. Under NRS Title 14 Chapter 171.123, any peace officer (e.g. NDOW Game Warden, county sheriff deputy, city police agencies) may detain a person that has committed, is committing or is about to commit a crime (e.g. possession of state listed prohibited wildlife [NAC 503.110] or plant [NAC 555.010] species). A person must not be detained longer than is reasonably necessary to ascertain his identity and the suspicious circumstances, and no longer than 60 minutes.

NDOW Game Wardens, as deputized by the USFWS, can enforce federally listed prohibited animal species laws [Lacey Act 50 CFR 16.11-16.15] if prohibited organisms are transported across state lines. Within the state of Nevada, NRS 503.597 states that it is unlawful to introduce or remove aquatic life or wildlife, including their spawn, eggs, or young and a Game Warden may enforce the statute if aquatic organisms are observed being transported. NDOW maintains the Operation Game Thief Hotline at (800) 992-3030 which may be used to report prohibited species. The penalty for possessing prohibited organisms in Nevada may be as high as six months in jail and a $500 fine.

Nevada Division of State Lands (NDSL)

http://www.lands.nv.gov/

The NDSL leads the State of Nevada's programs to protect Lake Tahoe, including coordination of the Nevada Tahoe Resource Team (NTRT). NTRT is an interagency team dedicated to preserving and enhancing the natural environment in the Lake Tahoe Basin. The Division also administers other special programs as well as provides staff assistance to the Nevada TRPA and the State Land Use Planning Advisory Council.

Nevada Division of State Parks (NDSP)

http://www.parks.nv.gov/

The NDSP plans, develops and maintains a system of parks and recreation areas for the use and enjoyment of residents and visitors. The Division also preserves areas of scenic, historic and scientific significance in Nevada.

Tahoe Area Sierra Club Group

http://motherlode.sierraclub.org/tahoe

The Sierra Club is widely known as a watchdog group for development and land management issues in the Tahoe Basin, however, is has increased efforts to spread the word about invasive species to its members in the Tahoe area. Outreach efforts include a prominent link on their website and local presentations on AIS impacts.

Tahoe Interagency Executive (TIE) Committee

The TIE committee is comprised of executive level representatives from regional (e.g. Tahoe Regional Planning Agency and water improvement districts), state, and federal agencies and organizations. TIE is involved in updating the Lake Tahoe Region Environmental Improvement Program (EIP) which includes AIS components. The committee also reviews cost estimates associated with AIS activities in the EIP. With respect to this AIS management plan, it is anticipated that TIE will continue supporting efforts of the LTAISWG and LTAISCC.

Tahoe Keys Property Owners Association (TKPOA)

http://www.tahoekeyspoa.org

The TKPOA is a non-profit mutual benefit corporation whose members include lot owners within the Tahoe Keys Development. The Board of Directors is dedicated to managing the aquatic weed problem in the Keys. The TKPOA Water Company has an active program of mechanically harvesting aquatic weed in the lagoons and monitors water quality under the requirements of a National Pollutant Discharge Elimination System (NPDES) water circulation permit. The TKPOA is a cooperative partner with the Aquatic Invasive Species Working Group and is working with USFS, USFW, CDFG, TRPA, TRCD, USDA, and other partners and stakeholders to develop a more viable solution to manage/eradicate aquatic weeds and invasive species in the Keys, and to prevent the introduction of new invasive species in the Keys and the Tahoe Basin. A significant current effort of the Working Group is to develop a program to evaluate various control techniques in the Keys lagoons. The TKPOA also continues to be involved in a cooperative data collection and sharing program with USDA, CDFG, TERC, and others.

Tahoe Resource Conservation District (TRCD)

http://www.tahoercd.org/

The TRCD was established in 1974 under Division 9 of the California Public Resources Code. The mission of the TRCD is to promote the conservation and improvement of the Lake Tahoe Basin's soil, water and related natural resources, by providing leadership, information, programs and technical assistance to all land managers, owners, organizations and residents. It is tasked with protecting land, water, forests, and wildlife through activities such as erosion control, runoff infiltration, native landscaping, water conservation, and wildlife enhancement. Prompted by infestations of submersed invasive plants and the threat of quagga mussels, the TRCD ramped up AIS prevention and management efforts and are actively involved in the administration and implementation of AIS-related activities with other LTAISWG members.

Tahoe Regional Planning Agency (TRPA)

http://www.trpa.org

The TRPA was founded on a bi-state compact between California and Nevada, ratified in 1969 by the U.S. Congress (P.L. 91-148, 83 Stat. 360) and amended in 1980 (P.L. 96-551, 94, Stat. 3235). In 1974, TRPA was designated an areawide planning agency under section 208 of the Clean Water Act. As such, the TRPA is tasked with developing and implementing the Water Quality Management Plan for the Lake Tahoe Basin (208 Plan). TRPA maintains water quality measures specified in the 208 Plan by limiting the impacts of tourism, ranching, logging, and development on the Lake Tahoe environment and enforcing environmental thresholds.

With respect to AIS, the 208 Plan states (Vol. I, page 154) that the use of insecticides, fungicides, and herbicides shall be consistent with the BMP Handbook (TRPA 1988, Vol. II), and that TRPA shall discourage pesticide use for pest management. The 208 Plan provides that only chemicals registered with the USEPA and the state agency of appropriate jurisdiction shall be used for pest control, and then only for their registered application. No detectable concentration of any pesticide shall be allowed to enter any Stream Environmental Zone (SEZ) unless TRPA finds that the application is necessary to attain or maintain its “environmental threshold carrying capacity” standards.

TRPA’s Governing Board is mandated to “set policy and to approve amendments to the Regional Plan”. In 1982, the Governing Board passed Resolution No. 82-11 to adopt environmental threshold carrying capacities for the Tahoe Region (cited in TRPA Code of Ordinances). TRPA’s Proposed Regional Plan and Environmental Threshold Carrying Capacity is currently being updated (TRPA 2008). According to the Draft Executive Summary, it will include language requiring in-lake and in-stream projects to address invasive species. Also included will be projects on prevention activities (boat washing, public education), research, monitoring, and even eradication (TRPA 2008). (http://www.trpa.org/documents/RP_Exec_Summary_4-09-08.pdf).

TRPA has several existing AIS prevention efforts. According to TRPA Code of Ordinances Chapter 79.3. B, all watercraft entering the waters of the Lake Tahoe Region are subject to inspection to prevent the introduction of AIS or owners face penalties starting at $5,000. Additionally, all boat launches (public and private) without a trained inspector are closed.

Section 83.2 of the TRPA's Shorezone Ordinance describes the review process for Proposed Possible Contaminating Activities in Lake Tahoe, particularly within Intake Source Water Protection Zones (i.e., areas within one-quarter mile of a drinking water intake structure). Examples of such activities include physical methods to control AIS that may result in increased turbidity or actions that result in increased coliform. TRPA shall not approve a project approved unless the project has appropriate best management practices (described in Section 25.2 of the Ordinance), the water purveyor accepts the project following review of a risk assessment, and the final determination has been made by TRPA with input from the appropriate State Health Department.

Tahoe Science Consortium (TSC)

http://www.tahoescience.org/

The Tahoe Science Consortium (TSC) is a partnership among five research organizations: 1) University of Nevada, Reno; 2) University of California, Davis; 3) The Desert Research Institute; 4) The US Forest Service, Pacific Southwest Research Station, and 5) the US Geological Survey, Carson Science Center. Established through a memorandum of understanding in August 2005, the primary objective of the TSC is to provide environmental managers and decision makers with comprehensive and well-synthesized scientific findings drawn from research, monitoring, and modeling. TSC efforts focus on promoting scientific advancement in the Lake Tahoe basin through science planning, independent peer review, and technical assistance. With regard to aquatic invasive species, TSC partners are active participants in the Lake Tahoe AIS Working Group and the AIS Coordinating Committee. In addition, scientists from various TSC partners are actively engaged in investigations to assess the potential for new introductions, quantify the extent of existing infestations, and assist management agencies in the development of effective control measures.

Tahoe Water Suppliers Association (TWSA)

http://www.tahoeh20.org

The TWSA is a regional partnership of Nevada and California Water Suppliers serving the Lake Tahoe region. TWSA members rely on Lake Tahoe as source for public drinking water. TWSA is one of many organizations in Lake Tahoe working to preserve the exceptional water quality of the lake. The mission of the TWSA is to develop, implement, and maintain an effective watershed control program in order to satisfy recommendations in watershed sanitary surveys, advocate for the protection of Lake Tahoe as a viable source of drinking water, and to satisfy additional state and federal requirements. With respect to AIS, the TWSA is particularly concerned about the introduction of quagga or zebra mussels to Lake Tahoe due to their ability to clog intake structures and potential to cause taste and odor problems. Additionally, control efforts that result in increased turbidity may impact filtration avoidance status as granted by NDEP.

Formed University of California (UC)

www.terc.ucdavis.edu

Formed in 2004, the Tahoe Environmental Research Center (TERC) is a center within the John Muir Institute of the Environment at UC Davis. The goals of TERC are to address water clarity loss, development, ecosystem management, and research through multidisciplinary and collaborative efforts. TERC publishes the annual *Tahoe: State of the Lake Report* which summarizes the lake's clarity, temperature, chemistry, and biology.

University of Nevada at Reno (UNR)

http://www.cabnr.unr.edu/chandra/Chandra_lab/AEAL_Homepage.html

Researchers at the Aquatic Ecosystem Analysis Laboratory (AEAL) at UNR are involved in several AIS-related projects to help restore and conserve aquatic ecosystems. Projects include: monitoring the movement and assessing the number of invasive warm water fishes, evaluating the invasion potential of New Zealand mudsnails and Quagga mussel to Lake Tahoe and the Lower Truckee River, evaluating the impacts of nonnative crayfish and Asian clam to the lake's ecology, and creating a baseline of benthic invertebrate production prior to increase invasions in Lake Tahoe.

Western Regional Panel (WRP)

http://www.fws.gov/answest/

The Western Regional Panel on Aquatic Nuisance Species was formed in 1997 to help limit the introduction, spread and impacts of aquatic nuisance species into the Western Region of North America. This panel of public and private entities was formed by a provision in the National Invasive Species Act of 1996 (P.L. 101-636), the amendment to the 1990 Act. There are 19 western states on the WRP, including California and Nevada. In May 2009, the WRP completed the Quagga-Zebra Mussel Action Plan for Western U.S. Waters (commonly referred to as "QZAP"). The objectives of QZAP are to "underscore the highest priority actins and resources needed to minimize impacts of these invasive shellfish to native species, water delivery infrastructure, and other vulnerable resources in the West."

Appendix B: Lake Tahoe AIS Vessel Inspection Implementation Plan 2009 – 2010

This product was prepared by:
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1 Introduction

The Vessel Inspection Program (VIP) is designed to help prevent the introduction of new aquatic invasive species (AIS) populations in the Tahoe Region, to control the spread of those populations that already exist and to prevent degradation of the Region. This Plan is being developed to define the duties of the boat inspector and describe the implementation of the inspection process. The program outlined in this document is intended to work with other plans and programs such as the watercraft decontamination and the Aquatic Invasive Species Outreach plan to prevent the introduction of AIS to the Lake Tahoe Region.

2 Proposed Relation to Blue Boating Program

Parallel to the AIS inspection program, the Tahoe Regional Planning Agency (TRPA) is proposing a Blue Boating Program which is intended to mitigate new shorezone development and maintain Lake Tahoe's status as an Outstanding National Resource Water. The Blue Boating Program will incorporate elements to insure that boats entering Lake Tahoe follow clean boating practices. Each vessel using Lake Tahoe will be required to have a sticker that identifies it as following these guidelines. The details of this program are available from TRPA.

A component of the Blue Boating Program is the inspection of vessels entering Lake Tahoe for clean bilges, heads, and out of water exhaust and issuance of a sticker. It is at this point that the Blue Boating Program and the AIS inspection program intersect. To make the most efficient use of resources, AIS inspectors would perform the basic Blue Boating inspection while doing the normal AIS inspection. Should the Blue Boating Program require inspections that significantly increase the amount of time taken for a joint inspection, AIS inspection staffing levels would be augmented.

3 Background

Zebra mussels were first discovered in the U.S. in Lake St. Clair, near Detroit, in 1988. Since that time zebra mussels have spread at an alarming rate through much of the Eastern United States. Quagga mussels were until recently thought to be a type of zebra mussel and have spread from the Great Lakes to Arizona, Nevada and California. The New Zealand mud snail was first found in the Snake River Drainage, Idaho and Washington, in the 1980's. Since that time this snail has spread too many areas of the west, including California's central valley and the Owens River. Billions of dollars have been spent nationwide dealing with the maintenance issues, AIS infestations present, and countless dollars have been lost due to the economic impacts on tourism and recreation.

On January 6, 2007, quagga mussels were discovered in Lake Mead, Nevada and Arizona. Since that time, quagga and/or zebra mussel infestations have been discovered in Lake Mohave, Lake Havasu, reservoirs of the City of San Diego and in January of 2008, in the San Justo Reservoir in San Benito County, approximately 250 miles from Lake Tahoe. Boating in San Justo Reservoir has since been banned. Currently, Lake Tahoe and other lakes of the Tahoe Region are believed to be free of quagga and zebra mussels. However, zebra and quagga mussels and New Zealand mud snail pose a major threat to Lake Tahoe and other lakes of the Tahoe Region if they were to become established. Experts fear that these invertebrates could spread quickly through the Truckee River watershed and become a downstream threat to the City of Reno and Pyramid Lake. If zebra or quagga mussels or the New Zealand mud snail were to infest Lake Tahoe, they could:

- Have severe impacts on aquatic biologic communities, fishing and recreation.
- Foul facilities such as docks and ramps.
- Encrust boats and clog engines.
- Litter beaches with sharp odiferous shells.
- Cause impacts to water quality that would increase costs for drinking water treatment.
- Clog drinking water and other intake pipes, increasing maintenance costs to these systems.

In addition, other AIS such as Eurasian watermilfoil, curlyleaf pondweed, large mouth bass and other warm water fish species currently exist in Lake Tahoe. The existence of these species in the Lake has started to disrupt the food web, has impacted water clarity and has had a deleterious effect on native fish populations such as the Lahontan redside shiner and speckled dace. Eurasian watermilfoil also creates a habitat that the New Zealand mud snail and warm water fishes can thrive in.

Aquatic invasive species present a growing worldwide problem. New invasive species are continually being identified. Impacts from AIS can be extreme and affect ecosystems, recreation, and economics. AIS infestations are generally permanent, and where control and/or eradication is possible it is very costly; prevention is the only good strategy to combat them. Education is critical because aquatic invasive species generally need humans to move anywhere but downstream. As a result the TRPA Governing Board unanimously passed a resolution adopting the need for emergency action for AIS control in May of 2007.

4 Regulations

Preventing the introduction of aquatic invasive species into the Lake Tahoe Region is a function of outreach, education, voluntary action by the boating public, and regulation. Interaction with the public during inspections has shown that the vast majority of the boating public is aware and concerned about the spread of AIS. The level of cooperation with inspections by the boating public has been high and this greatly simplifies prevention efforts. The TRPA Code of Ordinances includes several sections relating to AIS efforts that could be applied if needed.

4.1 Current Code

TRPA Code of Ordinances, Chapter 79.3 contains regulations relating to the prevention of invasion by aquatic invasive species. Invasive species are defined in the TRPA Code as:

> …species, both aquatic and terrestrial, that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy.

Aquatic invasive species shall include but not be limited to: zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena bugensis*), Eurasian water milfoil (*Myriophyllum spicatum* L.), curlyleaf pond weed (*Potamogeton crispus* L.), and large mouth bass (*Micropterus salmoides*).

TRPA Code of Ordinances, Chapter 79.3. A relates to the transport, introduction and launching of watercraft that is contaminated with aquatic invasive species.

> Prohibition: The transport or introduction of aquatic Invasive Species into the Lake Tahoe Region is prohibited. Further, the launching of any watercraft contaminated with aquatic Invasive species into the waters of the Tahoe Region is prohibited.

TRPA Code of Ordinances, Chapter 79.3. B makes it mandatory to submit to the inspection of watercraft prior to launching when an inspector is present, makes decontamination mandatory when the watercraft is judged by an inspector to be contaminated, and closes boat launching facilities when an AIS inspector is not present.

> (1) An owner operator of a Boat Ramp or other Boat Launch Facility (exclusive of single family residences) shall close the ramp or facility to launching of watercraft at all times when the provisions of subsection (2) have not been or cannot otherwise be provided or met.
>
> (2) All watercraft, motorized and non-motorized, including but not limited to boats, personal watercraft, kayaks, canoes and rafts, shall be subject to an inspection prior to launching into the waters of the Lake Tahoe Region to detect the presence, and prevent the introduction, of Aquatic Invasive Species. An inspection under this section is valid only if performed by a trained inspector pursuant to Tahoe Regional Planning Agency standards and requirements for Aquatic Invasive Species inspections.
>
> (3) All watercraft inspected in subsection (2) shall be subject to decontamination if determined necessary by an inspection under 79.3 B (2). A watercraft shall launch only if the required decontamination is performed and completed by a trained individual pursuant to TRPA standards and requirements for Aquatic Invasive Species decontamination and launch is

authorized by a trained inspector pursuant to TRPA's standards and requirements for Aquatic Invasive Species Inspections.

(4) All watercraft inspected in compliance with subsection (2) and decontaminated in compliance with subsection (3) are subject to a fee to pay for the inspection and/or decontamination and other program costs. The TRPA Governing Board will review and approve the fee amount and structure annually (Effective June 1, 2009).

5 Inspection Protocol

5.1 Training and Designation of Inspectors

All TRPA designated inspectors will be trained to meet TRPA standards prior to conducting any inspections. Tahoe Resource Conservation District (TRCD) and TRPA staff are currently certified by the 100th Meridian Initiative to provide inspection and decontamination trainings. TRCD and TRPA staff will provide the needed trainings to certify contractors and launch facility staff.

5.2 Location at Launch Facility

Watercraft inspectors will position themselves in such a manner as to insure that watercraft are inspected efficiently, this may require that inspectors move along any queue that forms at the facility to inspect, rather than waiting for the watercraft to come to the inspection station. The exact position of the inspector will be site and season specific. Arrangements with the facility superintendents have been made in order to facilitate this effort. Inspection stations should provide inspectors with protection from the elements both winter and summer.

5.3 Equipment

Boat inspectors will wear uniforms provided by TRPA or its designee and shall include a shirt with an identifiable insignia of the entity they represent and the title of "Boat Inspector." If the uniform shirt does not include the title, inspectors are required to have identification stating such. It is recommended that the inspectors be supplied with the following equipment:

- Cellular phone
- Flashlight
- Telescoping mirror
- Clipboard
- Survey forms
- Pen
- Magnifying lens
- Digital camera
- AIS Incident and Emergency Contact information

5.4 PROCEDURES

Inspection

The following section gives details about various aspects of the inspection of watercraft.

One of the purposes of the inspection is to educate the watercraft operator of the adverse impacts of AIS and steps that they can take to reduce the risk not just to Tahoe, but to other lakes that they use as well. To accomplish this outreach, inspectors will begin the inspection by educating the boater about AIS issues then follow with a brief survey designed to asses the risk a particular watercraft presents[1].

Inspectors will survey every watercraft operator entering the launch facility at which they are stationed, while they are on duty; unless the watercraft is sealed on the trailer (see inspection sealing section below). The inspection form is included in Attachment B-1.

The survey includes questions such as: where are the boaters from, what is the last body of water the boat was in, how long has their boat been out of the water and did they clean, drain and dry their boat. Based on the information received, the inspector will determine if a more thorough examination of the boat is warranted. Inspectors also need to be observant and compare the answers with visual clues. For example, the boater states they are local, but their license plate is from Arizona.

If the inspector determines that the risk level is low, the boater will then proceed as they normally would. If it is determined they present a high risk[1], the inspector will ask for permission to conduct the more thorough examination. If permission is not granted, the owner will be further educated regarding the threat aquatic invasive species pose. They will also be informed of the regulations pertaining to aquatic invasive species (State, Federal and TRPA) and that they would not be able to launch until an inspection is conducted. If the owner/operator launches despite a request for inspection, they may be subject to a minimum $5,000 penalty for a violation of TRPA's Code. Article VI (1) of the Tahoe Regional Planning Compact.

Assuming permission is granted, the inspector will look at the hull, engine, trailer, live and bait wells, bilge, etc. for any signs of contamination in accordance with the training the inspector received. If any organisms are found or if there is standing water in any part of the boat, the owner would be instructed to have their boat decontaminated. Boat wash units are located around the Lake. Their locations may be changed; however inspectors will be informed of their locations so that watercraft operators can be told where to go for decontamination. If the owner launches without decontamination once an inspector has determined that decontamination is needed, the owner/operator of the watercraft may be subject to a minimum $5,000 penalty for a violation of TRPA's Code. Article VI (1) of the Tahoe Regional Planning Compact (see regulation section). If decontamination is not available, or if adult mussels are found on the vessel, the inspector

[1] A high risk boat is any boat that has been in any of the known waterways infested with either quagga/zebra mussels or New Zealand mud snails, these boats shall always be inspected, unless they have a valid "tear off" portion of their survey, or intact inspection seal. The list of infected waterways changes quickly and requires frequent updates, and as such is not included in this plan. An updated list is included on the inspection form. Further, a high risk boat is also one that has been in any body of water outside of the Tahoe Region within the last seven days.

will not attempt to detain the vessel as that is beyond the authority of the inspector and TRPA Code, but rather will ask the vessel operator to wait while the inspector contacts the inspection supervisor on call who will then call the appropriate law enforcement authorities.

Role of State and Local Law enforcement

The role of the AIS inspector is to complement efforts by state agencies with the jurisdiction over boating and AIS introduction, California Department of Fish & Game or Nevada Department of Wildlife. TRPA and USFWS have engaged the local governments in the Lake Tahoe Basin to encourage the passing of local ordinances that address AIS introduction and vessel inspection. Agreements are also being developed with local law enforcement agencies in California to assist when these local laws regarding AIS are being violated. Local law enforcement agencies in Nevada already have the ability to enforce state game law and agreements with these agencies are being pursued. This assistance by local law enforcement will be needed as the Warden resources of both states are stretched thin.

The Watercraft Inspectors should follow the recommended approach to conducting the surveys and inspections found in the Tahoe RCD Boater interaction protocol.

The majority of boaters will be cooperative. However, should the boater refuse any part of the inspection, the inspector is to inform the boater that inspections are mandatory and that they will not be permitted to launch unless they complete the inspection. Should the boater continue to refuse the inspection and proceed to launch, the inspector shall inform the boater that if they launch they are subject to significant monetary penalties and the inspector shall contact their supervisor who will contact Game Wardens and/or the TRPA for follow up and enforcement.

***** ***The inspector shall never use foul or obscene language or gestures under any circumstances. The utmost professionalism is required at all times. Always be courteous and professional.***

Inspection sealing of watercraft

Upon haul out from any launch facility, or after an off ramp inspection has been performed, a designated inspector will provide at the operators request an inspection seal that designates the watercraft as having been inspected at Lake Tahoe. The purpose of this seal is to indicate that the boat received an inspection prior to launching into Lake Tahoe. This will allow boats that last launched into Lake Tahoe to pass quickly through inspection thus reducing the work load for inspectors and improving the experience of boaters at launch. The rational for this seal is that boats that have been inspected and launched in Lake Tahoe and have not been to another water body outside the Tahoe Basin, pose no threat to Lake Tahoe and do not require further inspection.

The seal will consist of a numbered band unique to Lake Tahoe that is attached between the boat and trailer at haul out, or off ramp inspection station, such that it will be broken on launching, but not so tight as to break during transport. The seal should be attached by the by the inspector, once permission has been given by the operator of the vessel. The inspector should also verify the bilge plug is pulled and there are no weeds or other attached matter that could spread the AIS currently in Tahoe (i.e. Asian clams and curly-leaf pond weed) to other lakes.

If a boat appears at a launch facility with an intact seal from Lake Tahoe, the designated inspectors or other facility staff may allow that boat to launch after confirming that the seal is unbroken. This complies with TRPA Code of Ordinances 73.B (2), which requires that a launch facility can only be operated when boats can be inspected by a designated inspector. As agreements can be reached with other operators of other non-contaminated water bodies, sealed boats from those water bodies may also be included.

6 Inspection Locations and Schedule

This part of the implementation plan was developed following meetings with both the Private and Public owned launches on Lake Tahoe. It is designed to meet the needs of the boating public while preventing the introduction of aquatic invasive species. The inspection hours and locations represent full implementation at high water and are subject to change based on funding and lake level.

6.1 Infrastructure

The majority of launch facilities on Lake Tahoe require no additional infrastructure to limit operating hours to when inspections can be performed. There are several ramps that require gates or other methods to close ramps during non-operating hours. These gates and other infrastructure will need to be in place to meet TRPA code. In addition to the infrastructure required to limit operating hours, updated signage will be needed at all launch facilities to explain that it is illegal to launch after having refused an inspection. As of the date of this draft of the plan several ramps have installed infrastructure in response to the TRPA code, and there is funding available to install infrastructure at the remaining ramps.

6.2 Reservation System

To address the access by early morning users in the most efficient way possible, a reservation system will be created. This system will consist of a hotline that boaters can call one day in advance to schedule an early (5 am in summer) launch time at specific locations around Lake Tahoe for the following morning. Once a reservation is made for any given day and ramp, subsequent callers requesting an early launch that day either be directed to the previously reserved ramp, or, if staffing allows, additional ramps may be opened early that day. If launch facilities wish to have their personnel participate in the reservation system to increase the availability of their ramp to early morning users, they may provide a trained inspector to be on call. The reservations for a ramp with its own on call inspector could be made either through the overall reservation system or by calling the facility directly, at the operator's discretion.

Note: While the reservation system is currently an option, there are no plans to implement it at this time.

6.3 LATE HAUL-OUT OPTION

Operators have coordinated with emergency responders in their respective locations to allow emergency access. In addition, launch operators may choose to also have a non-emergency late haul-out option. Should the launch operator chose to participate in this program, a gate code that would be good only for that day would be given out to boaters when they launch. The code would be entered into the gate lock when the inspector leaves for the day and changed the following day. This gives boaters that cannot get back to the ramp on time the ability to haul-out, however as no inspector will be there when the boat is hauled out, these boats will not be sealed with an inspection seal (see above) and will need to be re-inspected at the next launch. An alternate methodology for late haul-out is currently being discussed that would use one or more contracted businesses to be available to open the gates after normal operating hours.

Note: As of the date of this draft a late haul-out option is not in use, however Obexer's Marina is planning to adopt this option for late haul out.

6.4 CHANGES IN SCHEDULE AT PUBLIC LAUNCHES

All scheduled hours for operation and inspection at public launches are subject to change due to inclement weather and water level. The determination to open public ramps will come from the ramp operator (i.e. Nevada State Parks for Cave Rock). The ramp operator will call the Tahoe RCD on call inspector or other designated staff who will then inform the scheduled inspector of the closure, post the announcement on the AIS hotline and inform TRPA staff who will update the website to reflect the decision to change operating hours. This last step is critical as it will inform the boating public of any changes.

6.5 WINTER LOCATIONS AND SCHEDULE

The following Boat Launch Facilities are normally **closed** to the launching of watercraft from Oct 2nd to April 30th, though operating seasons are variable and at the discretion of the operator. These facilities will not require that inspectors be present during that time:

- El Dorado Beach
- Lakeside Marina
- Camp Richardson Marina
- Timber Cove
- Sand Harbor
- Tahoe Vista
- Coon Street
- North Tahoe Marina
- Sierra Boat Company
- Sunnyside Marina
- Homewood High and Dry
- Meeks Bay Marina
- Fallen Leaf Marina
- Echo Lakes Chalet (closed by snow)

The following Boat Launch Facilities are **open (7 days a week) during normal hours of operation** to the launching of watercraft from October 2nd to May 1st, though operating seasons are variable and at the discretion of the operator. Inspections will be provided by facility staff during normal hours of operation:

- Tahoe City Marina (no ramp)
  - Hours of operation: 8am to 5pm, weekend launches by appointment only, hours subject to change.
- Obexer's Marina
  - Hours of operation: 8am to 6pm, subject to change.
  - Reservations available 6 am – 8am
- Tahoe Keys Marina
  - Hours of operation: 8am to 6pm, subject to change.
  - Reservations available 6 am – 8am
  -
- Sierra Boat Company (no ramp)
  - Hours of operation: 7:30am to 4:30pm, subject to change.

The following Boat Launch Facilities are **open 7 days a week** during hours to the launching of watercraft from Oct 2nd to May 1st, though operating seasons are variable and at the discretion of the operator. Inspections will be conducted by dedicated inspectors during that time (one inspector per day):

- Cave Rock
  - Hours of operation: 6 am to 4pm, weather permitting
- Ski Beach
  - Hours of operation: 8 am to 4pm, water level and weather permitting
- Lake Forest
  - Hours of operation: 6 am to 4pm, water level and weather permitting

6.6 WINTER STAFFING

To meet the schedule and locations above will require seven full-time inspectors, additional part time inspectors and launch facility staff.

6.7 SUMMER LOCATIONS AND SCHEDULE

The following Boat Launch Facilities are planned to remain **closed** to the launching of watercraft during the summer 2009 season due to low water, though operating seasons are variable and at the discretion of the operator. These facilities are not anticipated to require inspectors be present during the summer season:

- El Dorado Beach
- Camp Richardson Marina
- Tahoe Vista
- Coon Street

The following Boat Launch Facilities are **open 7 days a week** to the launching of watercraft from May 1st to Oct 1st and inspections will be provided by facility staff during normal hours of operation:

- Timber Cove
  - Hours of operation: 8am to 6pm, 9-5 after Sept 1, subject to change.
- North Tahoe Marina
  - Hours of operation: 8am to 6pm, 8-5 after Sept 1, subject to change.
- Sierra Boat Company
  - Hours of operation: 7:30am to 5pm, subject to change.
- Sunnyside Marina
  - Hours of operation: 9am to 5pm, subject to change.
- Homewood High and Dry
  - Hours of operation: 7am to 6pm, after Sept 8am to 5 pm, subject to change.
- Fallen Leaf Marina
  - Hours of operation: 8am to 6pm, subject to change.
  - Reservations available?
- Echo Lake Chalet
  - Summer hours of operation available on website, fall hours 10am – 4pm, subject to change.

The following Boat Launch Facilities are **open 7 days a week** to the launching of watercraft from May 1st to Oct 1st and inspections will be provided by both dedicated inspectors and facility staff during normal hours of operation:

- Lakeside Marina
  - Hours of operation: 8am to 6pm, subject to change.
- Camp Richardson Marina
  - Hours of operation: 8am to 8pm, subject to change.
- Obexer's Marina
  - Hours of operation: 7am to 8pm, subject to change
- Tahoe Keys Marina
  - Hours of operation: 8am to 6pm, subject to change

- Meeks Bay Marina
  - Hours of operation: 8am to 6pm, subject to change
- Cave Rock
  - Hours of operation: 5am -8pm
- Sand Harbor (open subject to lake level)
  - Hours of operation: 6am -8pm
- Ski Beach
  - Hours of operation: 7am to 8 pm
- Lake Forest
  - Hours of operation May 1 to May 17: 6am -8pm
  - Hours of operation May 18 to Oct 1: 5am -11pm

6.8 Proposed summer staffing

The current grant funding levels will only fund 15 full time equivalent dedicated inspectors for the summer season 2009. The schedule above reflects this level of funding and the participation in the program by facility staff.

7 Introduction to AIS Inspection Fee

This section of the inspection plan was produced to explain the collection of fees to provide long term funding to support inspections. The goal of this proposal is to create a long term source of funding for the inspection program that is effective, equitable, and has the most limited effect on boating in Lake Tahoe.

The fees proposed here are based on the number of inspectors required to implement an off-ramp inspection program that is scheduled to be implemented in 2010. The actual hours of operation and number of launch facilities involved will vary as lake levels change.

The fees proposed in this document are planned for implementation during the summer of 2009. The goal is to begin the collection of fees while the inspection program is still funded by existing grants, so that a small cash reserve can be carried into the first months when the inspection program is fully fee funded. These fees will also be reviewed by TRPA staff and the TRPA Governing Board on a yearly basis and adjusted either up or down to meet the staffing needs of the program as conditions change.

8 Inspection Fee Structure

8.1 Partner Agency and Stakeholder Input

The TRPA developed this fee structure with the input of our partner agencies and public stakeholder groups, although not all suggestions of our partners made it into the final approved fee schedule. Meetings were held with partner agencies and boat facility operators prior to any decision on the approval or denial of this program by the TRPA Governing Board.

8.2 Methods and Assumptions for Calculating Fee Structures

Boating data

Multiple sources of boating data were consulted to get estimates on the number of boats that are launched on Lake Tahoe and therefore the number of inspections needed and for which a fee could be charged.

The earliest study that was consulted was "Boating in Nevada 1986-1988" which was performed by Biocentric, Inc. for the Nevada Department of Wildlife. This study concluded that in 1988 there were a total of 53,127 boats using Lake Tahoe. The study further estimated the percentage of launches from public launches in California and Nevada at 19% or 10,094 launches. This figure of 19% only included Incline, Sand

Harbor, Cave Rock, CA Dept. of Boating and Waterways at North Tahoe and Coast Guard Launch. There are ten additional launch ramps, plus other launch facilities that are part of the inspection program, thus this is an underestimation of the number of launches that can be expected to be inspected as part of this program.

The second study that was consulted as a source of boating data was "Watercraft Use Study, Lakes of Tahoe" which was performed by Hagler Bailly, Inc. for the TRPA, Nevada Division of Wildlife, California Department of Boating and Waterways, and the California Air Resources Board. This study concluded that in the 1998 boating season there were 99,325 motorized boating trips on Lake Tahoe. This study also concluded that 52.3% of these trips originated from a publicly or privately run launch ramp for a total of 51,947 launches. This was a lake wide study that included the entire suite of launch facilities included in the inspection plan. The Nevada Division of Wildlife indicates that there has been a roughly 4% decrease in boating since 1998 (Messmann pers. com.) so the estimate for launches to expect on Tahoe during the 2009 boating season is 49,869.

The third source of boating data comes from the inspections that were conducted at launch facilities during the 2008 boating season. While this dataset is the least complete as far as the number of sites sampled, it yields important information as to the percentage of boats that are only launched in Tahoe. Of the approximately 9,000 inspections conducted 50% of the boaters claimed that they only launched in Tahoe.

Assumptions and Calculations

If one looks at the total number of launches in the 1988 study (10,094) and compares the number of launch sites sampled, roughly 25% of the total number in the Tahoe Basin though several of the busiest, it does not seem unreasonable to assume that the total launches in the Tahoe Basin in 1988 would have been in the neighborhood of 30,000 launches.

While this figure of 30,000 launches is significantly less than the 51,947 launches estimated in 1998, this perhaps could be accounted for by the increase in recreational use of the Tahoe Basin over 10 years due to increased population in the surrounding metropolitan areas. This assumption is further backed up by the increase in total boats on the lake during those 10 years, from 51,947 boats in 1988 to 99,325 boats in 1998.

Assuming that the total number of launches at ramps is 49,869, 50% using the percentage of Tahoe only boats from the inspections in 2008 this gives us 24,934 inspections of vessels that last launched in another lake. These are the watercraft that would not have an inspection seal and therefore are subject to inspection and fee.

The next assumptions are not about the number of inspections that will be performed, but rather about the inspection process itself, and relate to the equability of the program.

One of these assumptions is that vessels that last boated in Tahoe are not an AIS risk to Tahoe. This means, boats entering Lake Tahoe that have an inspection seal verifying that they were last launched in Lake Tahoe would not need to be inspected and therefore would not be subject to a fee. This would not apply to vessels coming to Fallen Leaf Lake or Echo Lake from Tahoe as these lakes are currently free of some of the AIS that are found in Tahoe.

The second of these assumptions is that larger more complex boats will require a longer than average time to inspect and therefore are justified in paying a larger fee. The complexity of inspection increases when vessels are equipped with ballast tanks or bags, and/or live wells. Vessels that have these features would be charged a higher fee. Charging fees based on length and complexity of vessels is not without precedence. Lake County, CA charges inspection fees based on both length and complexity.

There are data that give an indication of the percentage of each size of vessel that use Lake Tahoe. The most recent study was performed in 2006 by Responsive Management for the TRPA. Table B-1 shows the percentages of vessels by size as found by the 2006 study.

Table B-1. Percentage of Vessels by Length

Vessel Length	Percentage (n= 215)
Less than 12 feet	1%
12 to 15 feet	7%
16 to 20 feet	36%
21-25 feet	46%
26-30 feet	7%
31-39 feet	1%
40 or more feet	2%

Budget needs for AIS inspection program

For 2009, inspections will continue to be conducted at the boat ramps. Under this strategy, privately run facilities would collect the same fee as public launches, but use the fee to fund their own staff to conduct inspections, data entry, and other related tasks. The inspectors at these facilities would be approved by TRPA by means of a Memorandum of Understanding (MOU) and would be subject to quality control and assurance measures.

The budget needs for the inspection program were calculated based on the off-ramp implementation strategy. This strategy is to centralize inspections at 4 to 6 locations within the Tahoe Basin and augment the personnel at public ramps to monitor and install inspection seals.

The centralization of stations would reduce cost from the full implementation plan previously vetted that required 32 inspectors and a $36.00 inspection fee for the most common vessels. The use of centralized stations would require an estimated 21 full and part-time personnel when lake level permits all public launches to be open.

For the purpose of estimating the program budget, seven to 10 full time inspectors will be required for the winter season. The cost for these inspectors, including benefits and other costs, is approximately $27,000 per month.

In addition to the salary cost of inspectors, there are equipment, database, administration and coordination costs that need to be funded by this inspection fee. The total cost for the non-administrative support services for centralized inspections is approximately $40,000, while administrative support is $147,000, This is approximately 22 % of the total program costs.

he inspectors, plus the required support services is estimated to cost $680,000 per year for the centralized system. This figure does not include lease/rental costs for centralized stations. We have no estimate of that cost and, to date, a number of sites have been offered at no cost.

8.3 Fee Structure

Based on the data, assumptions and calculations above and the goal of funding the AIS inspection program, the following fee structure was adopted for 2009. This structure, as shown in Table B-2, is on a sliding scale based on length of vessel with an extra charge for ballast tanks and livewells.

Table B-2. Proposed fee structure with sliding scale based on vessel length, no charge for sealed vessels and extra charge for livewells and ballast tanks at centralized inspection stations.

Vessel Category	Inspection fee	Estimated number of inspections in each category*
Non-motorized vessels	$0	N/A
Vessels with intact inspection seal	$0	N/A
Vessels up to and including 16 feet	$10	1,620
Vessels over 16 feet to 25 feet	$30	16,605
Vessels over 25 feet to 39 feet	$40	1,620
Vessels over 39 feet	$60	405
Vessels containing ballast tanks/ bladders/livewells	$10 additional fee	4,151
Total Funding:	**$654,000**	

* Based on estimated 24,401 inspections of vessels that did not last launch in Tahoe, and using percentages of boats in each category from 2006 Tahoe Boat Survey

9 Logistics and Accounting

The infrastructure and accounting portions of the fee implementation plan will be developed following meetings with both the Private and Public owned launches on Lake Tahoe. It is designed to meet the needs of the boating public while preventing the introduction of aquatic invasive species.

9.1 Inspection Seals and Fees

The existing Lake Tahoe Basin Aquatic Invasive Species Vessel Inspection Implementation Plan includes the use of inspection seals to determine which vessels have last launched into Lake Tahoe and therefore pose no threat to the lake. These vessels are able to launch into Lake Tahoe with only a cursory inspection to verify that the seal is unbroken. The current fee structure does not charge a fee to those vessels that have an unbroken seal. The identification number of each seal will be recorded at each launch to take account of the number of vessels that are launched without fee and to track the use of seals.

9.2 DATABASE AND FEES

As part of the AIS inspection program, TRPA is developing an online database to track numbers and patterns of vessels using Lake Tahoe. This database will also be used to track inspection seals, and Blue Boating related data. This database could also be used to as a method to track fees paid. This database will be available to both AIS inspectors and launch operators for data entry and tracking.

9.3 INFRASTRUCTURE

Fee Collection

Currently there are two fee collection infrastructure methods that can be incorporated into this plan. The overall goal is to have fee collection methods that are the most efficient possible for the boating public.

The first method involves collection of fees by the private launch facility operators. Under this alternative, the operator will collect the fee appropriate to the length of vessel and issue a numbered receipt to the vessel operator that will then be presented to the inspector and entered into the dataset with the other information on the vessel. Under this scenario the private launch facility operator will keep the fee to cover all staffing needs.

The second method involves collection of fees by both inspection and public facility staff. Under this alternative, inspections would be able to be paid for by cash or, by cash and debt/credit cards depending on the facility in question.

9.4 ACCOUNTING AND CONTROL

The complexity of collecting the fee and the importance of accounting for public funds means that the appropriate control and accounting measures need to be in place when the proposed fees are implemented. As with the logistics of fee collection, the particulars of accounting and control will require significant input from our partners to make them as efficient as possible. The accounting and control strategies will likely very between ramp locations. Staff is currently engaged with our partners to develop this program.

10 Program Evaluation

The inspection and fee program will require three forms of evaluation to ensure that it is operating efficiently and effectually.

10.1 Program Implementation

The first evaluation is that of program implementation. This evaluation will rely on both queries of the database to look for anomalies and review of on the ground implementation by TRPA staff. Examples of questions that will be asked to evaluate implementation are:

- Are inspectors and related support staff entering data in a timely manner?
- Are inspection seal numbers duplicated or used more than once?
- Are inspections being conducted in accordance with established protocols?
- Are inspections being conducted on every boat that is not sealed?

10.2 Program Effectiveness

The effectiveness of an AIS inspection program is not a simple thing to address. The program is effective only if it prevents the introduction of AIS by watercraft that pass though inspections. This is not to say that should new AIS become established in Lake Tahoe that this program was not effective. For many species there are other vectors for introduction, though trailered boats are the primary vector for most. The methods to evaluate the effectiveness of the program still need to be developed in cooperation with our partners.

10.3 Fee Evaluation

The inspection fee will be evaluated on annual basis to ensure that it meets the needs of the program with out being excessive. TRPA staff will bring a progress report annually to the Governing Board prior to the boating season. This progress report will include a year-to-date number of inspections performed and the results of implementation; effectiveness evaluations and current financial status of the program will also be included. In addition, TRPA staff will request of Governing Board to adjust the inspection fee as needed.

ATTACHMENT B – 1: VESSEL INSPECTION FORM

Inspector: Form #: | **Date:** | **Time:**

Launch Ramp Location:

Boat Registration # or Trailer License #:

Vessel Description:

Aware of AIS: Y or N (if Y, how, where?)

Owner Name, City & State:

How long has the vessel been out of the water? A ≤ week, **B** ≤ 28 days, **C** ≥28 days **Last Lake?** (not on list below)

Check any of the following waters launched with Vessel within the last 28 days:

Known *MUSSEL* Infested Water Bodies as of 5/18/09: Must perform inspection

○ CO River AQ. CA,UT,AZ,NV,CO	○ Lower Otay Resv. CA	○ Lake Havasu NV, AZ	○ Tarryall Resv. CO
○ Copper Basin Reservoir CA	○ Murray Reservoir CA	○ Central AZ Project Canal	○ Willow Creek Resv. CO
○ Dixon Reservoir CA	○ Olivenhain Resv. CA	○ Imperial Dam AZ	○ Electric Lake UT
○ El Capitan Reservoir CA	○ Parker Dam CA	○ Lake Pleasant AZ	○ Red Fleet Resv. UT
○ Irvine Lake CA	○ Rattlesnake Resv. CA	○ Salt River AZ	○ Lake Texoma TX
○ Lake Jennings CA	○ San Justo Reservoir CA	○ Grand Lake CO	○ Eastern US
○ Lake Mathews CA	○ SanVicente Resv. CA	○ Jumbo Lake CO	○ Midwestern US
○ Lake Miramar CA	○ Sweetwater Resv. CA	○ Lake Granby CO	○ Canada
○ Lake Ramona CA	○ Lake Mead NV	○ Pueblo Reservoir CO	○ Other
○ Lake Skinner CA	○ Lake Mohave NV, AZ	○ Shadow Mt. Resv. CO	○ Other

Known *SNAIL* Infested Water Bodies: Check boat, trailer, fishing tackle and equipment for mud or vegetation

○ American River CA	○ Lake Shasta CA	○ Owens River CA	○ San Lorenzo River
○ Calaveras River CA	○ Mokelumne River CA	○ Putah Creek CA	○ Russian River CA
○ Lake Hodges CA	○ Napa River CA	○ Sacramento River CA	○ Other

INSPECTION (Y- yes, N- no) Bilge Partial Full

☐ **Hull, Outdrive(s), Prop Shaft(s)-** Ms: Y N Vegetation: Y N

☐ **Transom-** Ms: Y N Vegetation: Y N	☐ **Live/Bait Wells-** Ms: Y N Vegetation: Y N Water: Y N
☐ **Engine/Generator(s)-** Ms: Y N Vegetation: Y N	☐ **Pitot Tubes, Trim tabs, Transducers-** Ms: Y N Vegetation: Y N
☐ **Bilge/Thru-hull Fittings-** Ms: Y N Vegetation: Y N Water: Y N	☐ **Anchor Rope/Locker-** Ms: Y N Vegetation: Y N Water: Y N
☐ **Trailer-** Ms: Y N Vegetation: Y N	☐ **Other-** Ms: Y N Vegetation: Y N
Is Bleach Decontamination necessary? Y/N **Is Hot Water Decontamination necessary?** Y/N *If yes, please refer to response card for procedure and call* **1-888-TAHO-ANS**	**Comments:**

Appendix C: Small Watercraft Screening Process

This product was prepared by:
U.S. Forest Service – Lake Tahoe Basin Management Unit

For more information please contact:
Richard Vacirca,
Forest Aquatics Program Manager
(530) 543-2768

The U.S. Forest Service – Lake Tahoe Basin Management Unit (USFS – LTBMU) developed a modified boat inspection program (termed "screening process") for small, non-motorized watercraft that launch from campgrounds, resorts, recreation residences, and other day-use facilities around Lake Tahoe. In most instances, private firms (termed "concessionaires") such as California Land Management (CLM) operate public recreation sites under species use permits and implement the screening process. The purpose of this program is to reduce the likelihood of AIS introduction from portable watercraft that would otherwise not be inspected by TRPA inspectors at fee-based boat launches. The screening process will be updated annually based on input from concessionaires and the LTAISWG through an adaptive management approach.

For consistency purposes the screening forms, which describe the modified inspection process, is available for state and municipal park management agency use where formalized boat inspection and decontamination is not currently occurring for small watercraft.

LAKE TAHOE BASIN MANAGEMENT UNIT

SCREENING PROCESS FOR AQUATIC INVASIVE SPECIES

Questions to be asked of all visitors with portable water craft. Please record answers to questions in the spaces provided.

1. Where has your vessel been within the last 28 days?
____

   a. See list of infected waterbodies on opposite page
   b. If vessel has been in one of these waterbodies go to no. 2

2. Has the vessel been completely dry for the last 3 days? _____

   a. If YES – have a good day
   b. If NO – please advise individual(s) not to launch until boat has been inspected and/or washed (see no.'s 4, 5 and 6 below)

3. ONLY IF a watercraft needs inspection, record:

Vehicle make and color: ___________________________
Vehicle license plate number: ________________________

4. Boat Inspections:

- Mobilize rec. site operator's designated inspector to conduct watercraft inspection.
- Refer to boat inspection schedule for TRCD location and staffing information or call 1-888-TAHO-ANS.
- IF a vessel launches without washing – please contact 1-888-TAHO-ANS with information including vehicle/vessel description and/or license plate number.

5. Public Boat Wash Locations:

West Shore
Meeks Bay Resort & Marina
Hwy. 89 – Approx. 15 miles north of the "Y" (junction of Hwy 89 and Hwy 50)

South Shore
Tahoe Regional Planning Agency
128 Market St.
Stateline, NV
775-588-4547

East Shore
Sand Harbor State Park
Hwy 28, 2 miles south of Incline Lake, NV

North Shore
Lake Forest Boat Ramp
Located 1.5 miles east of Tahoe City, off Hwy 28 on Lake Forest Road

6. Private Boat Inspection and Decontamination Location for Fallen Leaf Lake:

Fallen Leaf Lake Marina
Located on the south end of Fallen Leaf Lake
(530) 544-0787
DECONTAMINATION AND INSPECTION FEE = $10.00

KNOWN QUAGGA AND/OR ZEBRA MUSSEL INFESTED WATERBODIES:

CALIFORNIA

San Bernadino Co.
- Lake Havasu
- Colorado River at Parker Dam
- Copper Basin Reservoir

Riverside Co.
- Colorado River aqueduct @ Hayfield
- Lake Matthews
- Lake Skinner

Imperial Co.
- Imperial Dam

San Diego Co.
- Dixon Reservoir
- Lower Otay Reservoir
- San Vicente Reservoir
- Murray Reservoir
- Lake Miramar
- Sweetwater Reservoir
- El Capitan Reservoir
- Lake Jennings
- Oiivenhain Reservoir

Orange Co.
- Irvine Lake
- Rattlesnake Reservoir

San Benito Co.
- San Justo Lake

NEVADA
- Lake Mead
- Lake Mohave

KNOWN NEW ZEALAND MUDSNAIL INFESTED WATERBODIES:

CALIFORNIA
- American River
- Lake Hodges
- Mokelumne River
- Owens River
- Sacramento Delta
- Calaveras River
- Lake Shasta
- Napa River
- Putah Creek
- San Lorenzo River

NEVADA
- Lake Mead

KNOWN HYDRILLA INFESTED COUNTIES:

CALIFORNIA
- Alameda
- Calaveras
- Imperial
- Lake
- Los Angeles
- Madera
- Monterey
- Mariposa
- Nevada
- Riverside
- Santa Barbara
- San Bernardino
- San Diego
- San Francisco
- Shasta
- San Joaquin
- Sonoma
- Sutter
- Tulare
- Yuba

KNOWN LAKE TAHOE BASIN EURASIAN WATERMILFOIL, CURLEYLEAF PONDWEED AND/OR ASIAN CLAM INFESTED SITES[1]:

- Tahoe Keys and associated lagoons
- Taylor Creek Marsh
- Ski Run Marina
- Zephyr Cove
- Osgood Swamp
- Meeks Bay/Marina
- Emerald Bay
- Lower Truckee River
- Upper Truckee River
- Quail Lake

[1]Additional screening for aquatic weed infestation risks will occur only at Fallen Leaf Lake campground, Angora Lake Resort and Echo Lake boat ramp.

Appendix D: Contributors and Resources

1 Authors and Reviewers

The Lake Tahoe Region AIS Management Plan was drafted by staff from Tetra Tech, Inc. Project management was conducted in the Rancho Cordova, CA office and a team of aquatic ecologists and economists were assembled from the Portland, OR and Seattle, WA offices (Table D-1). Appendix E Potential Economic Impacts was reviewed by Dr. Travis Warziniak (Table D-4).

Table D-1. Tetra Tech, Inc. Staff Contributors

Name	Position	Role/Expertise	Contact Information @tetratech.com
Toni Pennington, PhD	Aquatic Biologist	Coordination, Documentation, Project Manager	Toni.Pennington
Robert Plotnikoff	Senior Water Quality Specialist	Documentation	Robert.Plotnikoff
Harry Gibbons, PhD	Senior Aquatic Ecologist	Coordination	Harry.Gibbons
Jack Carroll, P.E.	Engineering Program Manager	Project Manager	Currently with USACE
Ridge Robinson	Senior Economist	Economic impacts	Ridge.Robinson
James Carney	Water Resources Economist	Economic impacts	James.Carney
Darlene Siegel	Biologist	Documentation	Darlene.Siegel
Jeff Barna	Biologist	Documentation	Jeff.Barna

2 Stakeholders and Contributors

Valuable input on current AIS prevention, control and research activities were provided by members of the Lake Tahoe AIS Working Group (LTAISWG) and the Lake Tahoe AIS Coordination Committee (LTAISCC) (Table D-2 and Table D-3), respectively). The roles of each group are summarized in Appendix A. Additional input was provided by resource managers and researchers from across the U.S. (Table D-4).

Table D-2. Lake Tahoe Aquatic Invasive Species Working Group[1] and Partners

Organization	Name	Position	Contact Information
Allegro Communications	Michelle Sweeny	Principal	msweeny@progresswithclarity.com
California Department of Fish & Game	Jason Roberts[‡]	AIS Coordinator, Region 2	jdroberts@dfg.ca.gov
	Kevin Thomas[‡]	District Fisheries Biologist	kthomas@dfg.ca.gov
California Department of Parks & Recreation, Sierra District[1]	Tamara Sasaki	Senior Environmental Scientist	tsasaki@parks.ca.gov
	Lisa Fields	Environmental Scientist	lfields@parks.ca.gov
California State Lands Commission[1]	Marina Brand	Assistant Chief, Division of Environmental Planning & Management	brandm@slc.ca.gov
	Eric Gillies	Staff Environmental Scientist	gilliee@slc.ca.gov
California Tahoe Conservancy	Tricia York	Environmental Improvement Program Coordinator and Science Liaison	tyork@tahoe.ca.gov
California Trout	Jenny Francis	Regional Director	jfrancis@caltrout.org
Lahontan Regional Water Quality Control Board	Doug Smith, PG	Senior Engineering Geologist, Chief of TMDL/Basin Planning Unit	dfsmith@waterboards.ca.gov
League to Save Lake Tahoe[1]	Carl Young		carl@keeptahoeblue.org
	Nicole Gergans	Program Advocate	Nicole@keeptahoeblue.org
Nevada Division of State Parks[1]	Peter Maholland	Conservation Staff Specialist	pmaholland@parks.nv.gov
Nevada Department of Wildlife[1]	David Catalano[‡]	Wildlife Biologist III, Western Region	dcatalano@ndow.org
Tahoe Environmental Research Center[1]	Christine Ka Lai Ngai	Research Scientist	cngai@cabnr.unr.edu
	Marion Wittmann, PhD	Post-doc Researcher	mwittman@ucdavis.edu
Tahoe Keys Property Owners Association[1]	Harry Dotson	Director, Board of Directors	harrydotson@sbglobal.net

Table D-2 cont.

Organization	Name	Position	Contact Information
	Rich Lehnert	Tahoe Keys Resident	richlehnert@msn.com
Tahoe Regional Planning Agency[1]	Jeff Cowen	Community Liaison	jcowen@trpa.org
	Rita Whitney	Threshold Monitoring Program Manager	rwhitney@trpa.org
	Ted Thayer[‡]	Natural Resource & Science Team Leader	tthayer@trpa.org
Tahoe Resource Conservation District	Dave Roberts	District Manager	droberts@tahoercd.org
	Nicole Cartwright	Invasive Species Program	ncartwright@tahoercd.org
	Kim Boyd	Invasive Species Program Manager	kboyd@tahoercd.org
Tahoe Science Consortium	Zach Hymanson	Executive Director	redfir@sbcglobal.net
Tahoe Water Suppliers Association	Madonna Dunbar	Executive Director	mod@ivgid.org
University of California – Davis, Cooperative Extension[1]			
Davis Department of Environmental Science and Policy	Holly Crosson	AIS Education/Outreach Coordinator	hacrosson@ucdavis.edu
University of Nevada - Reno	Sudeep Chandra, PhD		Sudeep@cabnr.unr.edu
US Department of Agriculture, Agriculture Research Services[1]	Lars Anderson, PhD[‡]	Aquatic Weed Research Leader	lwanderson@ucdavis.ed
US Department of Agriculture, Forest Service, Lake Tahoe Basin Management Unit[1]	Barak Shemai	Fisheries Biologist	bshemai@fs.fed.us
	Celcilia Reed	Noxious Weed Coordinator	ccreed@fs.fed.us
	Richard Vacirca	Forest Fisheries Biologist	rvacirca@fs.fed.us
	Sarah Muskopf	Aquatic Biologist	smuskopf@fs.fed.us
US Fish and Wildlife Service[1]	Steve Chilton[‡]	Lake Tahoe Aquatic Nuisance Species Coordinator	Steve_chilton@fws.gov

[1] Indicates membership per the LTAISWG Cooperative Memorandum of Understanding included in Attachment D-1

[‡] Lake Tahoe Region AIS Management Plan review subcommittee

Table D-3. Lake Tahoe Aquatic Invasive Species Coordination Committee

Organization	Name	Position	Contact Information
California Department of Fish & Game	Kevin Thomas‡ (for Stafford Lehr)	District Fisheries Biologist (Senior Environmental Scientist)	kthomas@dfg.ca.gov (slehr@dfg.ca.gov)
California Department of Parks & Recreation, Sierra District[1]	Tamara Sasaki	Senior Environmental Scientist	tsasaki@parks.ca.gov
California State Lands Commission	Marina Brand	Asst. Chief, Environmental Planning and Management Division	brandm@slc.ca.gov
	Eric Gillies	Staff Environmental Scientist	gilliee@slc.ca.gov
Lahontan Regional Water Quality Control Board	Daniel Sussman‡ (for Doug Smith)0	Environmental Scientists (Senior Engineering Geologist, Chief of TMDL/Basin Planning Unit9	dsussman@waterboards.ca.gov (dfsmith@waterboards.ca.gov)
Nevada Department of Wildlife	David Catalano‡	Wildlife Biologist III, Western Region	dcatalano@ndow.org
Nevada Division of State Lands	Charlie Donohue	Deputy Administrator, Dept. of Conservation and Natural Resources	cdonohue@lands.nv.gov
Tahoe Resource Conservation District	Nicole Cartwright	Acting Program Manager Lake Tahoe Invasive Species Program; Chair LTAISWG	ncartwright@carcd.org
Tahoe Regional Planning Agency	Ted Thayer‡	Team Leader, Natural Resources & Science	tthayer@trpa.org
Tahoe Science Consortium	Zach Hymanson	Executive Director	redfir@sbcglobal.net
US Department of Agriculture – Agricultural Research Service	Lars Anderson, PhD‡	Plant Physiologist	lwanderson@ucdavis.edu
US Fish & Wildlife Service	Steve Chilton‡	Lake Tahoe Aquatic Nuisance Species Coordinator/Chair, LTAISCC	Steve_Chilton@fws.gov
US Forest Service – Lake Tahoe Basin Management Unit	Holly Eddinger	Supervisory Forest Biologist, Life Sciences Group Program Leader, Ecosystem Conservation Department	heddinger@fs.fed.us
‡ Lake Tahoe Region AIS Management Plan review subcommittee			

Table D-4. Additional Information and Support

Organization	Name	Position	Contact Information
California Department of Food & Agriculture	Patrick Akers	Program Manager	pakers@cdfa.ca.gov
Center for Lakes & Reservoirs, Portland State University	Robyn Draheim-Waldeck,	Research Technician	rdraheim@pdx.edu
	Vanessa Morgan	Research Assistant	vhoward@pdx.edu
	Mark Sytsma, PhD	Director	sytsmam@pdx.edu
	Steve Wells	Research Assistant	sww@pdx.edu
Idaho State Dept. of Agriculture	Amy Ferriter	Invasive Species Coordinator	aferriter@agri.idaho.gov
Nevada Dept. of Environmental Protection	Andrea Seifert	Staff Engineer	aseifert@ndep.nv.gov
Oregon State University	Ron Griffiths, PhD	Ecologist Affiliate Professor	ron.griffiths@oregonstate.edu
San Francisco Estuary Project	Karen McDowell, PhD		kmcdowell@waterboards.ca.gov
Tahoe Regional Planning Agency	Paul Nielsen	Branch Chief	pnielsen@trpa.org.
Texas Parks & Wildlife Department	Earl Chilton, PhD	Aquatic Habitat Enhancement Program Director	earl.chilton@tpwd.state.tx.us
University of California - Davis	Holly Crosson		hacrosson@ucdavis.edu
University of Heidelberg	Travis Warziniak	Assistant professor of Environmental Economics	warziniack@eco.uni-heidelberg.de
University of Minnesota Sea Grant Program	Douglas A. Jensen	Aquatic Invasive Species Program Coordinator	djensen1@umn.edu
USFWS - Mountain-Prairie Region	Bettina Proctor (ret.)	Western Regional Panel Coordinator	bettina_proctor@fws.gov
USFWS - Mountain-Prairie Region	Erin Williams	Western Regional Panel Coordinator	Erin_Williams@fws.gov
USFWS - Pacific Region	Paul Heimowitz	ANS Coordinator	paul_heimowitz@fws.gov

Table D-5. Internet AIS Resources

Organization	Website	Notes
100th Meridian Initiative	http://www.100thmeridian.org/	
Aquatic Invasions Research Directory	http://invasions.si.edu/aird/	
Aquatic Nuisance Species Task Force	http://anstaskforce.gov	
California Department of Fish & Game	http://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=AquaticInvasiveSpecies	Clearinghouse for AIS updates (e.g. press releases, education/outreach materials, research notes)
	http://www.fs.fed.us/r5/ltbmu/documents/invasive-species/Not_Wanted_California_quagga.pdf	Quagga "Not Wanted" flyer
	http://www.dfg.ca.gov/invasives/quaggamussel/	California Invasive Species Program
	http://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=AquaticInvasiveSpecies	Invasive Species Documents
California Environmental Protection Agency – State Water Resources Control Board	http://www.swrcb.ca.gov/npdes/aquatic.html	Information on aquatic herbicide use in California
International Conference on Aquatic Invasive Species	http://www.icais.org/	
Invasive Species Information Node	http://invasivespecies.nbii.gov/index.html	
Invasive Species Specialist Group (ISSG)	http://www.issg.org/	IUCN Species Survival Commission
Lake Tahoe Watershed Assessment Vols. 1 & 2	http://www.fs.fed.us/psw/publications/documents/gtr-175/	Dennis D. Murphy and Christopher Knopp, Editors
National Center for Research on Aquatic Invasive Species	http://www.glerl.noaa.gov/res/Programs/ncrais/	

Table D-5 cont.

Organization	Website	Notes
National Invasive Species Council	http://www.invasivespeciesinfo.gov/council/main.shtml	National Framework for Early Detection, Rapid Assessment, and Rapid Response to Invasive Species
National Sea Grant	http://www.seagrant.noaa.gov/themesnpa/aquaticinvasivespecies.html	
	http://www.sgnis.org/	Research publications and education materials; No new materials added due to budget constraints
Nevada Invasive Species Initiative	http://www.nv.blm.gov/invaders/default.htm	
US Department of Agriculture – National Agricultural Library	http://www.invasivespeciesinfo.gov/	National Invasive Species Information Network
	http://www.invasivespeciesinfo.gov/news/calendar.php?searchdate=2008	Invasive species conference and meeting calendar
U.S. Geological Survey	http://nas.er.usgs.gov/	USGS-Nuisance Aquatic Species
Western Regional Panel on Aquatic Nuisance Species	http://www.fws.gov/answest/index.htm	*Quagga-Zebra Mussel Action Plan for Western U.S. Waters* (QZAP)

ATTACHMENT D - 1: LTAISWG MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (MOU) is made and entered into by the signatories.

I. AUTHORITY

This Memorandum of Understanding is made and entered into by (partial list - for a complete list of signatories see Attachment A):

- Tahoe Resource Conservation District;
- Tahoe Regional Planning Agency;
- Lake Tahoe Basin Management Unit, USFS;
- Nevada Division of State Parks;
- California State Parks Sierra District;
- U.S. Fish & Wildlife Service;
- Nevada Department of Wildlife;
- Tahoe Keys Property Owners Association;
- UC Davis Tahoe Environmental Research Center;
- University of California Cooperative Extension;
- Agriculture Research Services
- California State Lands Commission
- League to Save Lake Tahoe

hereinafter referred to as Principal Parties, Parties or Party, or Partner(s); and other Parties according to the terms of this Memorandum of Understanding, Section V.

II. PURPOSE

The purpose of this Memorandum of Understanding is to establish the Lake Tahoe Aquatic Invasive Species Working Group (LTAISWG) and define the terms and conditions under which the LTAISWG will cooperate and coordinate activities necessary to prevent the introduction, establishment, and spread of non-native aquatic species in the Lake Tahoe Basin. These activities shall focus upon the exclusion, detection, eradication, and suppression of priority aquatic invasive species using an integrated approach. The signatory agencies and organizations will cooperate in developing coordinated work plans and seeking funds to support the activities of the LTAISWG. The LTAISWG will work in partnership with the Lake Tahoe Basin Weed Coordinating Group (LTBWCG) to coordinate efforts and comprehensively address common issues.

III. GEOGRAPHIC SCOPE

The geographic scope of the LTAISWG includes the entire Lake Tahoe watershed and the administrative boundaries of the U.S. Department of Agriculture, Forest Service, Lake Tahoe Basin Management Unit.

IV. GOALS

LTAISWG members recognize that aquatic invasive species infestations within the Lake Tahoe Basin reduce biological, recreational and economical values and have negative impacts upon the environment. A coordinated approach to identifying existing populations, standardizing monitoring and removal techniques, coordinating prevention, and educating the public will result in a more effective effort to reduce or eliminate aquatic invasive species infestations. Responses to aquatic invasive species infestations will utilize all viable scientific alternatives that will best minimize further infestations in the Lake Tahoe Basin. Accomplishing the above goals will require the following:

1. EDUCATION: Increase public and staff awareness of aquatic invasive species.
2. EXCLUSION: Exclude aquatic invasive species from the Lake Tahoe Basin.
3. PREVENTION: Prevent the establishment of new aquatic invasive species infestations and spread of existing aquatic invasive species infestations.
4. CONTROL: Promote the effective management or eradication of designated species.
5. INFORMATION EXCHANGE: Share technical information regarding control methods, locations, new infestations, project success amongst parties and with other regional and local working groups.
6. COOPERATION: Facilitate development of cooperative agreements for local aquatic invasive species management which include opportunities for shared funding sources, resources, materials, personnel including volunteers, expertise, equipment, etc.

V. UNDERSTANDING

Now, therefore, in consideration of the above premises, and within each entity's budget and staffing limitations, it is mutually agreed upon and understood by and among the parties to the MOU that:

1. Partners will meet as needed for the purpose of developing, documenting, implementing, and updating a coordinated plan to detect, map, and control

harmful aquatic invasive species infestations in the Lake Tahoe Basin using the methods of integrated management.

2. Partners will participate in the implementation of the coordinated plan by developing and implementing an annual work plan.
3. Insofar as it is compatible with each Party's primary mission and statutory responsibilities, all parties shall use their best efforts to secure the funding needed to carry out the coordinated plan and annual work plan. Each project that requires specific funding to be implemented shall be the subject of a separate project-specific agreement between the Parties responsible for its funding and implementation.
4. Partners will provide data and information on the distribution of aquatic invasive species and methods of monitoring and control for sharing with all Partners through a centralized database.
5. This MOU may be extended or amended as necessary by mutual consent of the Parties by execution of a written amendment signed and dated by all Parties. This MOU will be reviewed every five (5) years and extended if necessary.
6. Any Party may terminate its participation in this MOU by providing 60-day written notice to all other Parties.
7. This MOU in no way restricts the involved Parties from participating in similar understandings and/or activities with other public or private agencies, organizations, and individuals.
8. This MOU shall be effective upon execution of a Signature Page by a minimum of two (2) Parties and shall remain in effect for five (5) years from the date of execution, or until terminated by the Principal Parties.
9. Additional participants, including interested property owners, property managers, special districts, non-profit entities and members of the public may become part of the Lake Tahoe Aquatic Invasive Species Working Group by execution of a Signature Page, subject to ratification by a majority of the existing participants.
10. <u>NON-FUND OBLIGATING DOCUMENT:</u> Nothing in this MOU shall obligate signatories to this MOU to obligate or transfer any funds. Specific work projects or activities that involve the transfer of funds, services, or property among the various signatories to this MOU will require execution of separate agreements and be contingent upon the availability of appropriated funds. Such activities must be independently authorized by appropriate statutory authority. This MOU does not provide such authority. Negotiation, execution, and administration of each such agreement must comply with all applicable statues and regulations.
11. To the extent allowed under Federal Tort Claims Law, each Party shall defend, indemnify, and hold harmless each of the other Parties, their officers, employees and agents from any and all liability, loss, expense

(including reasonable attorneys' fees) or claims for injury or damages arising out of the performance of this MOU but only in proportion to and to the extent of such liability, loss, expense, attorneys' fees, or claims for injury or damages are caused by or result from the negligent or intentional acts or omissions by the indemnifying Parties.

12. This MOU may be executed in one or more counterparts, each of which shall be deemed an original.

13. FREEDOM OF INFORMATION ACT (FOIA). Any information furnished under this instrument is subject to the Freedom of Information Act (5 U.S.C. 552).

14. RESPONSIBILITIES OF PARTIES. The signatories to this MOU and their respective agencies and office will handle their own activities and utilize their own resources, including the expenditure of their own funds, in pursuing these objectives. Each party will carry out its separate activities in a coordinated and mutually beneficial manner.

15. ESTABLISHMENT OF RESPONSIBILITY. This MOU is not intended to, and does not create, any right, benefit, or trust responsibility, substantive or procedural, enforceable at law or equity, by a party against the United States, its agencies, its officers, or any other parties or person.

IN WITNESS WHEREOF, the Parties hereto have executed this MOU on the attached Signature Page as of the date when the second Party has signed the Signature Page.

Lake Tahoe Aquatic Invasive Species Working Group

Signature Page

____
Name of party

hereby agrees to be part of the Lake Tahoe Aquatic Invasive Species Working Group and agrees to comply with, and be bound by, the terms of the Memorandum of Understanding – Lake Tahoe Aquatic Invasive Species Working Group attached hereto and incorporated herein by reference.

The Party hereto has executed this MOU as of the date written below.

__________________________________ ___________________________
Signature Date

____
Printed Name

____
Title

____
Address

____
City/State/Zip

____
Phone

Please sign and date this page, make a copy for your files, and return to:

Tahoe Resource Conservation District
Lake Tahoe Aquatic Invasive Species Group
870 Emerald Bay Rd.. Suite #108
South Lake Tahoe, CA 96150

Attachment D - 2: Letter in support of forming the LTAISCC

TSC Tahoe Science Consortium
Addressing Science Needs in the Lake Tahoe Basin

291 Country Club Drive
Incline Village, NV 89451
Tel (775) 881-7566
Fax (775) 832-1673
www.tahoescience.org

September 18, 2007

Letter sent to directors, executive Officers, supervisors or chairpersons of the following entities:

- Lahontan Regional Water Quality Control Board
- California Department of Parks and Recreation
- California State Lands Commission
- California Department of Fish and Game
- Tahoe Regional Planning Agency
- Nevada Division of Wildlife
- Nevada Division of State Lands
- US Forest Service, Lake Tahoe Basin Management Unit
- US Fish and Wildlife Service
- US Department of Agriculture, Agriculture Research Service
- Washoe Tribe

Subject: Formation of a standing committee to lead an Aquatic Invasive Species program in the Lake Tahoe Basin

Dear Sir or Madam,

I am writing to request your agency's active participation in a standing committee to lead an Aquatic Invasive Species (AIS) program in the Lake Tahoe Basin. We are extending this request to agencies and entities with significant land management, resource management, regulatory, or cultural heritage responsibilities in the Lake Tahoe Basin. The initial charge of this committee is to provide high-level leadership and direction to the implementation of the Lake Tahoe AIS program. Committee members will be expected to understand the policy and management implications of AIS actions and work within the committee to ensure these actions are effective and consistent with their agency policies. Committee members may also work within their agency to expand or modify policies and management strategies as a means to expanding the tools available to the Lake Tahoe AIS program.

An AIS technical working group was established earlier this year. This working group is comprised of agency and stakeholder technical staff, consultants, and members of the science community who are all working to implement various AIS projects and activities. The technical working group will be the operating arm of the new standing committee, and the chairperson of the work group will be a member of the standing committee.

Over the last year numerous agency, stakeholder, and science representatives have been working to establish a comprehensive AIS program in the Lake Tahoe Basin. Efforts are underway or will soon be initiated to stop the spread of existing introduced species, including control of aquatic weeds and eradication of invasive fishes. Additional efforts aim to prevent new introductions (especially introduced invertebrates) and include education and outreach efforts critical to the success of the AIS program. Planning, monitoring, and focused research also are being funded to ensure this comprehensive effort has a firm, objective basis that is consistent with State and Federal mandates. Federal, State, local, and private funding has been secured and is sufficient to sustain AIS efforts over the next 2-3 years. The US Fish and Wildlife Service has initiated efforts to hire a biologist who will be based in the Lake Tahoe Basin and who will focus on the coordination and implementation of the AIS program.

We believe it is essential to establish a standing high-level committee that can work with the AIS technical work group to lead and implement a comprehensive AIS program in the Lake Tahoe Basin. This committee will help to ensure the efficiency and effectiveness of a sustained AIS program that meets all State and Federal requirements. Initially we expect this committee with need to meet once every two months at agency offices in the south shore area of Lake Tahoe. However, over the longer term we expect meetings might occur quarterly with intervening conference calls as required.

Active participation by a representative from your agency is considered critical to the success of this committee. We are targeting senior technical staff or senior managers to serve as representatives. It is expected that this person will have a firm understanding of your agency's policies and management strategies related to AIS issues. It also is expected that this person will be able to communicate with agency executives to confirm agency policies, priorities, and resource commitments related to AIS efforts in the Tahoe Basin.

Some of the agencies contacted may have individuals focused on aquatic invasive species issues. These representatives are especially appropriate, although we understand that these individuals will have statewide responsibilities which limit their ability to participate in this regional effort. Continuity and sustained commitment are critical to the success of this effort, so it may be appropriate to select a regional representative who can communicate with your statewide coordinator.

Lake Tahoe is a national treasure that is now degraded by established introduced species and further challenged by potential new introductions. We hope that you will give serious consideration to this request and provide a representative from your agency who can fully participate in this new committee. We would appreciate a response to this request by October 30, 2007. Please contact me at (775) 881-7561 if you have any questions or require further information.

Sincerely,

Zach Hymanson,
Executive Director

Cc: Jenny Francis (TRCD)
Phil Brozek (COE)
Tricia York (CTC)
Susie Kocher (UC Extension)

Appendix E: Potential Economic Impacts

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1 Objectives

This Economic Appendix to the Lake Tahoe AIS Management Plan documents the results of literature review, research, and analysis of potential damages (costs) associated with AIS at Lake Tahoe to help inform policy decisions regarding the potential costs and benefits of AIS management (or lack thereof).

The analysis presented in this report was focused on estimating the potential future impacts of AIS in Lake Tahoe to provide a direct comparison to future costs of AIS Management (prevention, detection, control, and /or eradication) to inform policy making. The future damage streams were evaluated over a fifty year period of analysis (2009- 2059) and all figures are presented in 2008 prices.

2 Economic Study Area

The study area for this economic evaluation focuses primarily on the Lake Tahoe Region as defined by the TRPA (TRPA Compact P.L 96-551).

2.1 Socioeconomic Setting

The Washoe Indians gathered on the shores of Lake Tahoe prior to pioneer discovery in 1844, but it wasn't until heavy silver prospecting began in the 1860s that a local economy began to take shape. Prospectors gave up as lodes waned, but already rich San Franciscans had heard of a pristine lake tucked away in the Sierra Nevada. Soon luxury inns sprang up on the lake to provide seasonal accommodations. Once the first modern era casino opened in 1944, the local economy brought in enough revenue to justify plowing the roads during winter for year round access to the lake. Soon the first permanent residents were living at Lake Tahoe. The combination of a pristine mountain sanctuary, a variety of high quality outdoor recreation opportunities, and resort attractions like gambling and luxurious hotels has made the Lake Tahoe Region an internationally known recreational destination (LTVA 2008).

The Lake Tahoe Region has drawn over three million visitors every year for over a decade and is now home to approximately 75,000 permanent residents (United States Census Bureau 2000) and. The main attraction at Lake Tahoe is its scenery. Local tourism surveys have identified that over 80% of visitors report that the pristine environment and natural amenities attract them to the region (TCSF 1996). A recent consumer survey for the TRPA concluded that visitors and residents in the Lake Tahoe Region chose it as a vacation destination or place of residence primarily because of the natural amenities and outdoor recreation opportunities provided in the basin (TRPA 2002).

With the multitude of recreation options available, tourism has steadily increased to the Lake Tahoe Region, increasing the permanent population and local revenue streams. It was estimated in 1999 that visitors to the Region spent over 400 million dollars in the Tahoe Basin annually (Nechodom et al. 1999). The threat that AIS pose to future recreational opportunities, the local tourism economy, property values, and added boat and pier maintenance costs is a concern within the region and the subject of this analysis.

2.2 Population

Population counts and population projections are available for El Dorado and Placer Counties in California, and Washoe and Douglas Counties and Carson City Municipality in Nevada. The four counties and the municipality were collectively home to about 1,015,000 permanent residents in 2007 and are predicted to grow to around 1,436,000 by 2026 (Table E-1).

Table E-1. Population History and Projection, Greater Lake Tahoe Area, 1990-2026

Jurisdiction	1990	2000	2007	2026[2]
El Dorado County, CA	126,000	156,000	176,000	237,000
Placer County, CA	173,000	248,000	333,000	479,000
Douglas County, NV	27,600	41,300	45,400	61,700
Carson City Municipality, NV	40,400	52,400	54,900	77,700
Washoe County, NV	255,000	339,000	406,000	580,000
Total	**622,000**	**838,000**	**1,015,000**	**1,436,000**
Source: United States Census Bureau 1990 and 2000. NSBDC, 2008. CA Dept. of Finance, 2008				

In order to estimate the population within the Lake Tahoe Region, population data from the 2000 census was assimilated for census tracts falling within the Region boundaries. In 2000, there were about 75,000 people living within the Lake Tahoe Region, of which the California counties accounted for about 67% and the Nevada jurisdictions the remaining 33% (Table E-2). Rural Carson City, Nevada has a very small population in the Region with most of its land designated open space or government parkland and is not included in the table.

Table E-2. Populations within the Lake Tahoe Region, 2000

Jurisdiction	Year 2000	% of Total 2000 Four County Population within Lake Tahoe Region
El Dorado County, CA	32,200	21%
Placer County, CA	18,000	7%
Douglas County, NV	6,100	15%
Washoe County, NV	18,700	5%
Total	**75,000**	**10%**
Source: United States Census Bureau 2000		

Within the Lake Tahoe Region, the densest communities/population centers are found at the south end of the lake on the California and Nevada sides at the South Lake Tahoe and Meyers areas, respectively. The average annual population compound growth rate for the Lake Tahoe Region was predicted to be about 0.4% per year from 2000 to 2010 (TRPA 2002).

[2] Referenced population growth projections are based on historical trends and do not attempt to project the indirect effects of any future condition of the lake on population growth.

2.3 Employment and Income

The working population in the Lake Tahoe Region derives as much as 60% of their wages from local sources (TRPA 2002). Table E-3 shows an estimate of over 66,000 direct jobs in the Lake Tahoe Region in 1999 resulting from tourism (Nechodom 1999). The data indicate that the stability and continued growth of the recreation and tourism sectors at Lake Tahoe is important to the stability and growth in the Region's economy.

The average median annual household wage, weighted by population, of the Lake Tahoe Region was $66,352 (United States Census Bureau 2000). In per capita terms, the weighted average was $33,409. Applying the weighted average annual per capita income to tourism induced employment estimate yields an estimate of annual tourism-induced employment-based income of approximately $2.2 billion.

Table E-3. Tourism Induced Direct Employment, Lake Tahoe Region, 1999

Economic Sector	# of Jobs	% of Total
Food stores	1,000	1.5%
Service stations	360	0.5%
Eating and drinking	4,040	6.1%
Miscellaneous retail	1,310	2.0%
Hotels and lodging places	15,000	22.6%
Amusement and recreation	5,290	8.0%
Subtotal (all visitor serving sectors)	27,020	40.7%
All other sectors	12,370	18.6%
Total	**66,420**	

Source: Nechodom (1999)

3 Potential Effects of AIS on the Regional Economy

As the regional economy of Lake Tahoe developed, local concerns grew that the Tahoe Region could become overcrowded and lose its scenic appeal. In 1968, the Tahoe Regional Planning Agency was formed to achieve and maintain defined environmental threshold carrying capacities (thresholds). Significant resources have been channeled into the simultaneous regulation of development while moving toward achievement of thresholds (LTVA 2008). A challenge lies in minimizing adverse impacts of the recreation industry, including introduction of AIS, on the lake's natural environment, which in turn is the major draw for the recreational visitation. Sustainable recreational visitation is vital to the local economy.

In 2007, the Lake Tahoe Region's natural and recreational amenities were estimated to draw about 3.9 million visitors (see Table 4). The 1999 Lake Tahoe Watershed Assessment reported that visitors spend an average of around $114 dollars per visitor day (Nechodom *et al.* 1999). This spending translates to local employment and income. In addition to supporting local jobs and generating income, the natural beauty and recreational utility at Lake Tahoe is reflected in property values within the region. Shoreline properties, in particular, are especially valuable and sensitive to AIS impacts. The lake also provides drinking water for around 34,000 residents and thousands of visitors in the Region, requiring an average annual daily flow of around 6.6 million gallons to be pumped from the lake between 2003 and 2006 (TWSA 2007).

AIS have the potential to negatively impact the local and regional economy in a variety of ways. For example, lake clarity, a unique feature of Lake Tahoe, may be indirectly affected by AIS. Recreational options can become constrained or lost, reducing the quality and quantity of the recreational experience (ANSTF 2008). Less recreational visitation will negatively impact the local tourism industry. Diminished recreation opportunities and degraded environmental conditions can adversely affect property values as well. AIS can also damage water supply intakes, requiring costly maintenance and repairs of intake pipes (Sprecher and Getsinger 2000). Similarly, AIS can result in the need for costly maintenance to boats, docks and marina floats in the lake (ANSTF 2008). AIS management will also add an additional critical funding requirement during an era of competing critical restoration funding requirements.

Limited research has been conducted on the economic impacts of AIS. Pimentel et al. (2004) is frequently cited as a source for a rough estimate of the nationwide losses due to AIS. Their work estimates the nationwide economic losses (damages plus control costs) from AIS at around $120 billion annually. A decade before Pimental's work, the U.S. Office of Technology Assessment (OTA) estimated the cumulative nationwide losses between 1906 and 1991 from invasive species in the United States at around $96.9 billion. Plants, fish, and aquatic invertebrates accounted for about $2.3 billion (OTA 1993). The differences in results of these two national impact estimates have been attributed to differences in methodology (Lovell and Stone 2005), damage categories included (for example, Pimental et al. [2004] values ecosystem services affected by AIS), and the increase in AIS prevalence and awareness. These often cited studies are included here as a backdrop to demonstrate the potentially huge economic impact of AIS to the nation. Some research has also been completed on impacts at individual lakes and for individual species. However, these studies usually only attempt to estimate one category of damage, such as to sport fishing or power generation facilities.

Data gaps are a persistent problem for those attempting economic analysis of AIS. As early as 1993 the U.S. Department of Technology Assessment reported that a lack of quantitative data on the impacts of AIS made reporting the associated economic losses an anecdotal process (OTA 1993). Reports on specific AIS cases in California and Nevada concur that while some study has been conducted on the various types of economic effects that AIS create, little documented knowledge of the magnitude of those effects exists (Eiswerth et al. 2000). Similarly, previous published literature has identified gaps in data necessary for estimating economic effects of AIS at Lake Tahoe. The 1999 TRPA Watershed Assessment found that there was a lack of region-wide estimates of recreation visitation levels. More specifically, they identified the need for tracking of visitation to specific recreation areas on the lake by community and recreation activity (Nechodom et al. 1999).

Though limited by the availability of existing data, this report documents an analysis of the potential range of economic impacts that could reasonably be associated with further AIS establishment and infestation in Lake Tahoe. The methodology employed herein is designed to aggregate pertinent existing data and present a reasonably conservative estimation of potential future damages associated with AIS at Lake Tahoe. Specific categories of potential impact evaluated include: recreation, tourism, property values, water supply, and boat and pier maintenance.

In the Summary of Potential AIS Economic Impacts (Section 4), damage estimates from each category are aggregated and presented in total present value and average annual terms. Damage streams over a fifty year period of analysis were estimated in 2008 prices and converted to their total present value using the U.S. Government Fiscal Year 2008 Federal discount rate for water resources study ($4^7/_8$ %) (USACE 2007). The total present value of the stream of damages for each category was also converted to its average annual value also by amortizing the present value over 50 years at the $4^7/_8$ % discount rate.

3.1 Recreation

Lake Tahoe provides visitors with various outdoor recreation options while at the lake. Among the five highest participation rates for visitors and residents alike are beach activities, walking, trail hiking, swimming, and sightseeing (Nozicka 2001). In order to better understand the lake's recreation and tourism patterns, it is useful to consider the activities preferred by visitors and residents. Visitors to Lake Tahoe tend to favor fewer activities than residents. Visitors tended toward the resort-like activities such as beach activities, swimming, shopping, sightseeing, pleasure driving, and gaming. Residents, in contrast, favored more outdoor activities such as hiking, biking, backpacking, power boating, fishing, and local cultural or sporting events (Nozicka 2001). Still, both groups tended toward activities provided by the lake and surrounding environment.

In order to estimate lake-related outdoor recreation visitation, data was compiled from visitation estimates at the USFS-LTBMU, CADPR, and NDSP. Data is collected at these agencies in the form of number of visitors per month[3].

To more closely approximate the visitation that is lake-related (and prone to AIS impacts), the visitation data was limited to include only the months of May through October. These six months represent the "summer" season, which favors lake recreation as opposed to mountain recreation seen in winter. While the CADPR and NDSP data were provided by month, the USFS data was only available on an annual basis. To approximate USFS summer season visitation, the CADPR and NDSP data during the summer months were referenced. This data showed that from 2000 - 2005 about 82% of visitation to the parks took place from May to October. Thus, the USFS annual data was reduced to 82% of its original value to approximate visitation during the six month summer season.

In 2007, there were an estimated 3.8 million visitors to the Lake Tahoe Region (Table E-4). Based on historical trends, and assuming current conditions at the lake remain constant, this number is expected to grow at a rate of around 1.6% a year for the next twenty years (TRPA 2007). Table E-4 presents historical visitation data.

[3] Given the methods by which the above agencies collected their visitation data, it was not possible to disaggregate visitation from regional residents and visitors who came from outside the region. As such, the data used in this analysis includes both resident recreation participants and visiting participants. The number is considered conservative because it does not include resident boaters who do not access the lake via public parkland.

Table E-4. Lake Tahoe Region Outdoor Summer Recreation Visitation Statistics

Year	U.S. Forest Service LTBMU RVD	CADPR	Nevada State Parks	Basin Total
1995	2,882,000	671,300	960,200	4,514,000
1996	2,999,000	903,000	885,900	4,787,000
1997	2,947,000	802,400	892,800	4,643,000
1998	3,152,000	713,000	562,100	4,427,000
1999	3,003,000	909,000	735,000	4,646,000
2000	3,005,000	885,100	787,100	4,677,000
2001	3,053,000	564,000	858,200	4,475,000
2002	3,102,000	647,000	895,600	4,645,000
2003	3,152,000	417,700	943,300	4,513,000
2004	3,202,000	573,300	632,400	4,408,000
2005	2,759,000	226,500	620,700	3,606,000
2006	2,803,000	313,000	613,800	3,730,000
2007	2,848,000	318,000	696,500	3,863,000
Source: USFS NVUM 2006, CA State Parks 2007, NV State Parks 2008				

Lake-related recreation activities are expected to experience the greatest impact from AIS infestation. Four major lake recreation activities were examined in this analysis: beach activities, swimming, boating, and fishing. Boating was broken down according to power boating and canoeing/kayaking. An additional potential impact of AIS at Tahoe is loss of water clarity. Tahoe's level of clarity is a unique feature and contributes greatly to the quality of the recreation experience.

Existing information relative to reductions in recreation participation/visitation as a result of AIS were not available for application in this study, thus were based on the author's best professional judgment.

Beach Activities

With over 40 public beaches, beach activities are a staple recreation activity at Lake Tahoe. In a recent recreation survey, 76% of respondents said they take part in beach activities when visiting the lake (Nozicka 2001). Not including swimming (which is accounted for in its own category) beach related activities include walking, hiking, volleyball/sports/games, picnicking, fire pits, relaxing, barbequing, sand play/sand castles, et cetera. Table 4 and growth rate projections yield a projection of 3.92 million visitors to Lake Tahoe in 2008. Given the results of the survey, this equates to an estimate of approximately 2.9 million people participating in beach activities during the 2008 summer season.

The continued presence and growth of AIS in Lake Tahoe will likely inhibit beach recreation opportunities and degrade the quality of the experience. AIS like Eurasian watermilfoil, mussels, and clams are especially limiting to beach recreation options. Invertebrate shells that wash onto the shore are hazardous to bare feet and pets. Additionally, decaying organisms, including aquatic plants and invertebrates, release foul odors and attract insects.

AIS invasion can also impact the beaches' positive aesthetic qualities. Water clarity, a famed characteristic of Lake Tahoe, is adversely impacted when Eurasian watermilfoil becomes established. In some situations where poor water quality exists, it has been documented that invertebrates may positively affect water clarity. However, it is not expected that they would have a beneficial effect in the clear waters of Lake Tahoe; especially in shallow areas near the beaches. This is because they could increase the light reflective colloid concentrations above existing levels.

The above impacts on the beach have had the effect of deterring people from recreating on other lake beaches following AIS infestations. It is reasonable to expect a 10-20% decrease in participation in beach activities as a result of AIS infestation.

Swimming

Another major activity by respondent level of participation at Lake Tahoe is swimming. According to Nozicka (2001), 62% of respondents reported participation in swimming while at Lake Tahoe. Visitors enjoy the pristine clarity of the lake's water and the many swimming beaches around the lake. The lake's bathymetry is such that swimming areas are shallow and large, making for great near-shore swimming. The participation survey and the 2008 visitation projection result in an estimate of approximately 2.4 million visitors who participate in swimming during the summer season.

However, the shallow nature of the swimming beaches means that AIS can drastically affect swimmers. Plants are the main concern for swimmers. Dense, vine-like plants like Eurasian watermilfoil is not just annoying to swimmers, they are hazardous. A swimmer can become entangled in milfoil, possibly leading to drowning. In addition, swimmers will shy away from beaches with milfoil, avoiding the weed-choked water (ANS 2008). As lake levels drop later in the summer, dense mats of the AIS growth may be left exposed and will decay, likely emitting noxious odors and will generally be offensive to swimmers. Aesthetically, decreasing water clarity will degrade the quality of the swimming areas. It is reasonable to expect a 20-80% decrease in swimming participation, depending on the density of vegetative growth.

Power Boating

Many residents own power boats of various sizes and types, including ski boats, luxury boats, fishing boats, personal watercraft, et cetera. A study published on the 1998 boating season reported approximately 99,300 power boat trips from launches and ramps (Hagler-Bailly 1999). In addition, there is a resident population that keeps their boat on the lake in slips and on buoys. There are an estimated 2,964 slips and 4,454 buoys on Lake Tahoe, creating an estimated 7,418 resident boats (Ted Thayer [TRPA], personal communication and TRPA 2004). Adjusting the number of trips to reflect the decline in visitation over this period, and assuming residents take 32 boat trips per year (4 trips per week over the four month peak summer season), yields an estimate of approximately 325,436 boat trips in 2008.

Power boating activities are expected to be less impacted by AIS (in percentage terms) than recreation activities that must take place on or near the shore like swimming. Still, power boating participation may be reduced 10 – 30% depending on the extent of aquatic vegetation in shallow areas. This estimation is based on the fact that AIS are unlikely to directly impact boating activities in the middle of the lake; however, getting from the shore to the middle will be challenging, particularly in areas with dense vegetation. Power boats will likely be able to continue operation, but the lake will begin to seem more crowded as all boaters must move further from shore to avoid the invasive vegetation that can harm propellers and make the water unfavorable to skiers.

Canoeing/Kayaking

The second boating category is canoeing/kayaking. According to Nozicka (2001), 26% of respondents reported participating in canoeing or kayaking. Using the estimated 3.92 million visitors in 2008, this translates to about 1 million non-motorized boating visitors. Canoeing and kayaking are likely to be most impacted by aquatic weed infestations because these activities are concentrated in the near-shore environments where the lake bathymetry is conducive to infestation, making paddling difficult. Weeds and other AIS can also impact water clarity, especially in nearshore areas. Because of this, a reduction ranging between 20 - 40% in this category is reasonably expected.

Fishing

The last recreation category discussed is fishing. Lake Tahoe supports self-sustained populations of at least four popular sport fish: lake trout, brown trout, rainbow trout, and Kokanee salmon (BoatTahoe.com 2008). Although these species are non-native to Lake Tahoe, they are considered desirable sport fish by the states of Nevada and California. The summer survey indicated that 20% of visitors to Lake Tahoe participated in fishing, amounting to around 914,000 fishing visits in 2008. Most anglers are likely to fish in the shallow areas of the lake that are more susceptible to AIS infestation, not the deep areas far from shore (BoatTahoe.com 2008).

Invasive plants, invertebrates, and non-native fish, can adversely impact native fish populations. However, the impact of AIS to fisheries is more difficult to identify due to dynamic food web interactions. For example, a quagga mussel infestation can reduce primary production (phytoplankton), altering the food chain from the bottom up. Plants and invertebrates may impact fish populations in different ways. As mussels reduce food supply, fish may become stunted and fail to grow large enough for anglers to pursue.

Invasive plants on the other hand, alter fish populations by changing the vegetation cover within the lake. Invasive plants that grow near the shore, from the lakebed to the surface, shade out native submersed vegetation and tend to grow at a higher density. The result is increased cover for predatory non-native fishes (Michigan Sea Grant 2007).

Non-native fish considered invasive species in the Lake Tahoe Region AIS Management Plan include: bluegill, black crappie, brown bullhead carp, goldfish, green sunfish, and particularly largemouth bass. Predatory bass species pose an especially large threat to the lake's native fish. The explicit impacts of the other warm water fish at Lake Tahoe are not fully known; however, all invasive fish compete with native and sport fish for food resources. The presence of invasive fish has the potential to damage food webs and disrupt ecosystem function.

For angler's, invasive weeds can be aggravating and possibly damaging to a boat. Fishing from shore is not desirable when casting into a dense mat of aquatic vegetation such as Eurasian watermilfoil.

AIS not only reduce the availability of catchable fish, it also reduces the angler access to them. Fishing in weeds can require special lures to penetrate the canopy (Montgomery 2007). In fact, sport fishing in the Great Lakes reduced from 10 to 35% as the result of AIS (Lodge and Finnoff 2008). This impact range was used in this study to estimate impacts to sport fishing participation at Lake Tahoe with AIS infestation.

Summary of AIS Recreation Impacts

Given data gaps in the existing body of literature on recreation visitation and AIS, it was not possible to precisely estimate visitation effects related to AIS impacts on each recreation activity described above at Lake Tahoe. Specifically, the tendency of visitors to substitute activities was not quantifiable.

In the absence of published data, best professional judgment was used to estimate future recreation participation impact scenarios by activity. Table E-5 summarizes the estimated recreation participation impacts of AIS.

Table E-5. Estimated Recreation Participation Impacts

Activity	% Who Participate	Instances of Participation	Potential Reduction in Participation Percentage
Beach Activities	76%	2,979,200	10 - 20 %
Swimming	62%	2,430,400	20 - 80 %
Power Boating	28%	1,097,600	10 - 30 %
Canoeing/Kayaking	26%	1,019,200	20 - 40 %
Fishing	02%	784,000	10 - 35 %

Recreationists at Lake Tahoe likely participate in multiple activities during each visit. The participation data in Table 5 indicate the relative level of participation across lake-related activities. There was no data available to estimate the extent to which AIS impacts on individual activities might affect visitation to the Lake Tahoe Region. While AIS might preclude visitors from participating in some activities, they might still visit the Lake Tahoe Region to participate in others. However, available data does not exist for quantifying visitors' substitution of activities. As such, impacts to recreational visitation are expected to be less than the potential reductions in participation presented in Table 5, though how much less is not calculable. Given the lack of data on participant visitation response to AIS infestations, several hypothetical scenarios of visitation reduction were evaluated. These scenarios represent overall decreases in visitation that might be caused by AIS given the activity-specific decreases previously discussed. These overall reductions are conservatively less than reductions specific to any one activity in an attempt to account for substitution. Table 6 presents the range of visitor-day reduction scenarios evaluated in this study.

Reductions are subtracted from an estimation of recreation value in the Region of $63,704,200. This estimate was derived from visitor days provided by Nechodom (1999) and the value of a day of general recreation ($29.88 in 2008 dollars) in the USFS Pacific Region (Nechodom et al. 1999, Rosenberger and Loomis 2001). Table 6 presents the resultant ranges in potential future lost recreation values associated with each reduced level of visitation scenario. Table E-6 shows that an estimate of 2% visitation reduction yields a lost recreation value of approximately $1.3 million, while a median estimate of 5% yields approximately $3.2 million of lost recreational value.

Table E-6. Estimated Recreation Impact Scenarios

% Visitation Reduction	Reduction in Visitor Days	Lost Value
2.0%	42,640	1,274,083
5.0%	106,600	3,185,208
10.0%	213,200	6,370,416
Source: 2008 visitation data. Rosenberger and Loomis (2001)		

3.2 TOURISM

Revenue from recreation visitation to outdoor areas makes a large contribution to the national economy. The National Park Service estimated that, in 2006, park visitors spent 10.73 billion dollars in the local regions surrounding the National Parks (Stynes 2006). The Lake Tahoe Region encompasses recreation areas managed by the USFS, CADPR, NDSP, and local governments.

Tourism at Lake Tahoe is one of the local economy's largest sources of revenue (Nechodom 1999). Resort destinations like the hotel-casinos at Lake Tahoe generate revenue streams much larger than a stand-alone outdoor recreation area could (Nozicka 2003). And while these activities are popular and bring in tourists, the gaming industry is at the same time dependent on the recreation benefits that the lake provides. Without the recreation opportunities at Lake Tahoe, it would be less likely that gaming-oriented tourists from afar would choose to visit the Lake Tahoe Region instead of Las Vegas or Reno. This is evidenced by the intercept surveys conducted by Nozicka (2001). That study concluded that visitors to the Lake Tahoe Region prioritized activities that involved the natural environment, but they supplemented those activities with resort-oriented ones, like shopping and gaming. In addition, both residents and visitors felt that beach quality, beach access, maintenance, and forest access were the most important factors in determining the quality of their visitation experience, reinforcing the idea that it is primarily the lake and its natural setting that draws visitors (Nozicka 2001).

The total value of tourism to the Region can be estimated using recreation visitation data and an estimate of visitor spending. The Lake Tahoe Watershed Assessment represents the most complete research on visitation and visitor spending to date (Nechodom et al. 1999). The report uses an estimation of visitor days and dollars spent per visitor day in each of the Lake Tahoe communities to estimate tourism-derived spending in the Region. The report's estimate of visitor days was based on reported lodging rentals and the reported number of persons per room. Spending data was accumulated from visitor surveys (Nechodom et al. 1999). Still, visitor estimation remains a highly contentious recreation datum but has been estimated at 23 million (Fisk et al. 1997, Nechodom et al. 1999). This number stands in high contrast to the 2.6 million annual visitor days used in the Watershed Assessment, originally published for the LTVA (Strategic Marketing Group 1999).

Contributing to the data uncertainty is the fact that most federal and state park agencies are currently recording visitation data in number of visits rather than visitor days, which does not lend itself to straightforward economic analysis because no Lake Tahoe-specific model exists that allows the translation of number of visits into visitor days across all recreation types and sites. When this data becomes available, an estimation of the current tourism spending associated with lake-related outdoor recreation in the Lake Tahoe Region will be a more straightforward calculation. In its absence, the 1999 Watershed Assessment is the best available data. Table E-7 summarizes the findings of the 1999 Watershed Assessment, adjusted to 2008.

In order to adjust the 1999 report, annual visitor days are assumed to change in proportion to change in number of visits over the 1999-2008 period.

In order to estimate summer visitor days, the annual number was divided by 2, yielding an estimate of 1.5 million visitor days. Assuming that 50% of the visitation occurs during summer is a conservative assumption because previous reports have, using employment change as a proxy, estimated that a modestly larger proportion of the recreation occurs in summer (Nechodom et al. 1999). This summer reduction ratio is different than the 82% reduction used in Section 3.1 which was based on *outdoor* recreation visitation during the summer season. The 50% reduction is pertinent to *total* (including other activities such as gaming) Lake Tahoe Region visitation during the summer season.

Table E-7. Visitor Spending by County, May-October 2008

Jurisdiction	$/Visitor Day	Visitor Days	Spending
El Dorado County, CA	$145	360,000	$52,211,000
Placer County, CA	$180	240,000	$43,095,000
Douglas County, NV	$236	660,000	$155,628,000
Washoe County, NV	$230	240,000	$55,092,000
Total	-	**1,500,000**	**$306,026,000**
Source: 1999 Lake Tahoe Watershed Assessment, BLS CPI calculator			

The spending data reflects the value of tourism to the Lake Tahoe Region's economy. Given the research that has been conducted on consumer preferences in the Region (Nozicka 2001), it is apparent that a significant decrease in available recreation would adversely impact the regional tourism economy.

As illustrated in the Recreation section, an AIS infestation could cause significant decreases in recreation participation and losses in recreation value. These decreases have direct effects on the tourism revenue the Lake Tahoe Region receives. In order to assess possible impacts to the Region's tourism industry from AIS, it is assumed that tourism spending is proportional to visitation, meaning that a given percent decrease in visitation would result in the same percent decrease in visitor spending.

Table E-8 shows a range of percent reductions in visitation, and the corresponding reduction in spending. When considering the AIS impacts on the local economy's revenue, it is apparent that even a small reduction in visitation yields large losses in revenue. A decrease of 2% in visitation would result in about $6.1 million less dollars entering into the local economy in 2008 dollars. A median scenario like 5% could mean a decrease in spending of as much as $15.3 million dollars. At the upper end of the impact scenarios, a 10% reduction could result in a $30.6 million loss of tourism spending.

Table E-8. AIS-Induced Reduction Scenarios, 2008

% Reduction in Visitation	New Visitor Spending Level	Net Loss, $'08
2%	299,905,820	6,120,527
5%	290,725,030	15,301,317
10%	275,423,713	30,602,635
Source: Nechodom et al. (19990		

3.3 PROPERTY VALUES

The Region is comprised of around 60,000 parcels. Of those, about 50,000 are privately owned parcels. The remaining 10,000 are publicly owned; a combination of parks, recreation areas, government administration facilities, campgrounds, and open space. Not surprisingly, lakeshore parcels are the most expensive in the region. By area, privately owned lakefront property accounts for 27% of the total lakeshore. That 27% translates to over 5,600 parcels at an average size of 0.7 acres and with an average value of $852,878 per parcel. In contrast, there are 449 public parcels with an average size of 75 acres and an average value of $418,667 per parcel. Private property (including improvements) on Lake Tahoe's shore is valued at around $1.46 million per acre, while public property is valued around $19,200 per acre. In total, the value of lakefront property at Lake Tahoe is estimated at around $3.7 billion. Tables E-9 and E-10 provide an overview of the property in the Lake Tahoe Region. It should be noted that the dollar value per acre of private and public land was calculated using assessor's data, which likely underestimates the real value of public land because public land is not assessed for tax collection purposes. If the public land were to be analyzed using the value per acre of private land, waterfront public land value would amount to about $12.7 billion dollars. However, to be consistent in this analysis' reliance on existing data, and to maintain a conservative approach to valuation, public land was valued according to assessor's data in this analysis.

Table E-9. Summary Table: Private Property Values in the Lake Tahoe Region

Jurisdiction	Number of Parcels	% Private by Area	Average Value	Total County Value	Avg. Size (acres)	Total Acres	$ / Acre
El Dorado County, CA	2,190	24%	$838,700	$1,836,803,000	0.4	928	$1,980,000
Placer County, CA	639	61%	$1,233,300	$788,098,000	1.4	877	$898,500
Douglas County, NV	2,356	66%	$765,900	$1,804,569,000	0.5	1,121	$1,609,000
Washoe County, NV	463	6%	$892,000	$413,001,000	0.7	302	$1,366,000
All Lakefront Totals	**5,648**	**27%**	**$853,000**	**$4,842,471,000**	**0.7**	**3,229**	**$1,463,000**

Source: TRPA 2008, Washoe Co. Assessors Office, Douglas Co. Assessors Office, United States Census Bureau 2000

Notes:
1. Lakefront Average values were weighted by % parcels or acres per county
2. CA is a Prop 13 State. A sample of recently sold properties was used to determine average values for CA counties.
3. Public lands include all non-private lands, such as open space, recreation areas, campgrounds, and government buildings.

Table E-10. Summary Table: Public Property Values in the Lake Tahoe Region

Jurisdiction	Number of Parcels	% Public by Area	Average Value	Total County Value	Avg. Size (acres)	Total Acres	$ / Acre
El Dorado County, CA	108	76%	$634,000	$57,443,000	27.6	2,980	$19,300
Placer County, CA	39	57%	$431,000	$15,813,000	21.0	820	$19,300
Douglas County, NV	264	18%	$23,100	$5,896,000	1.2	306	$19,300
Washoe County, NV	38	94%	$2,478,000	$88,527,000	120.9	4,593	$19,300
All Lakefront Totals	**449**	**73%**	**$418,700**	**$167,679,000**	**75.3**	**8,700**	**$19,300**

Source: TRPA 2008, Washoe Co. Assessors Office, Douglas Co. Assessors Office, United States Census Bureau 2000

Notes:
1. Lakefront Average values were weighted by % parcels or acres per county
2. CA is a Prop 13 State. A sample of recently sold properties was used to determine average values for CA counties.
3. Public lands include all non-private lands, such as open space, recreation areas, campgrounds, and government buildings.

Lakeshore properties are the most likely to be adversely affected by AIS. Whether a property experiences direct impacts such as loss of a useable pier, or indirect ones like aesthetic losses due to murky water, property values on the lake will be affected by the presence of AIS. Assessment of lost property values is based exclusively on existing literature. In order to present a range of possible outcomes, damages were estimated using the percent property value reduction estimates published in existing studies (Table 11).

Three referenced studies for lakes around the country were used to estimate loss scenarios for private land. All of these studies focused on value reductions on private property only. Lake Tahoe's shoreline is 73% government owned. Therefore, while existing data did not allow for an estimate of public land value loss, it is evident that the large loss scenario for private land is a conservative estimate. Even a small loss per parcel on public lands would be substantial overall.

The existing literature facilitated a general estimation of losses in property value associated with direct impacts from AIS. These studies have estimated that AIS-induced reductions in value range from 5.4% to 20%. If the values are applied to lakefront private property, they equate to losses in value ranging from around \$260 million to \$968 million. Table 11 provides results of the three value reduction scenarios.

The assessed values of parcels located on the lakefront are very sensitive to the quality of lake access. For example, a pier is a high value added feature, as is beach. However, the benefits of either of these two features might be diminished by the presence of AIS. Invasive plants can make the property's lakefront un-swimmable by entangling the legs of swimmers. Both plants and invertebrates wash up on shore when they die, leaving a foul smelling beach full and sharp mussel shells. In addition, plants can ruin a pier's functionality by making access to it difficult without the use of a weedless propeller. Invasive plants can also destroy habitat for native species of fish and flora while fostering mosquito reproduction, making lakefront properties less attractive to anglers and beach visitors.

Aesthetics are also important in the valuation of a property. A home's value may decrease as a result of diminished aesthetics like dirty beaches and reduced water clarity (Halstead et al. 2003). Given the importance of clarity at Lake Tahoe, loss in clarity is likely to have an effect on a property's' value. Species likely to affect clarity most quickly are plant species such as Eurasian watermilfoil. Plants can decrease perceived clarity by direct shading and light absorption, and release of nutrients upon plant decay (resulting in increased algae growth). Existing literature on the effects of water clarity on property values report that a loss in one meter of clarity can result in property value declines raging from 2% (Ara et al., 2006), 1 to 6% (Boyle and Bouchard, 2003), and 3 to 8.5% (Gibbs et al. 2002).

Studies have shown that AIS (mussels, clams) can have a positive effect on clarity in some waterbodies; for example, in Lake Erie (USEPA 2008). However, Lake Tahoe presents a unique clarity case. Waterbodies referenced in the literature had dramatically reduced clarity than that found in Lake Tahoe. The Secchi depths at Lake Tahoe (about 70 feet in 2007) are much higher than those found in the various lakes studied in the literature. For example, Lake Erie had a Secchi depth of no more than 5 meters for measurements taken in the western basin between 2000 and 2005 (USEPA 2008). At the least, a one meter decrease in clarity at this lake would be equal to a 20% decrease. In contrast, a one meter decrease at Lake Tahoe would be equal to about a 4.3% decrease in clarity. While this decrease is noteworthy, it might not affect property values as quickly as by the effects of invasive nearshore plants.

Table 11 illustrates two things. First, that available literature varies widely in its estimation of AIS-induced property value reductions. Second, that even the conservative estimations predict a decrease in private property values of approximately $261 million. Higher impact scenarios show a decrease of up to $968 million. Additionally, reductions in property tax receipts by the surrounding jurisdictions will be associated with private property devaluation. Based upon 2007-2008 tax rates in the study area, property tax receipt reductions would range between $3.7 million and $13.8 million annually depending on the reduction scenario from Table E-11 (NTA 2005, Berrum 2008, Douglas County Assessor 2008, Placer County 2008, Zutter 2008).

In summary, this analysis of property value losses represents a conservative lower bound. Not considered in this analysis are the losses that would be experienced by parcels off the lakefronts. Furthermore, the value of public land in this analysis should also be considered a conservative lower bound. The tax receipt losses estimated above would also increase when considering non-lakefront parcels.

Table E-11. AIS Impacts on Private Property Values.

Lakefront Property	Current Value	% Reduction	Net Loss	New Value
Study 1	$4,842,471,000	5.4%	$261,493,000	$4,580,977,000
Study 2	$4,842,471,000	13.0%	$629,521,000	$4,212,949,000
Study 3	$4,842,471,000	20.0%	$968,494,000	$3,873,976,000
Sources: *Study 1.* Krysel et al. (2003), *Study 2.* Horsch (2008), *Study 3.* Halstead et al. (2003)				

3.4 Water Supply

The Lake Tahoe Basin is fed by 63 streams from the Sierra Nevada Mountains to the west and the Carson Range to the east. The only outlet from Lake Tahoe is the Lower Truckee River. Historically, the lake's water has been very high. Some Nevada water suppliers have been granted filtration avoidance status from the Health Division, program now overseen by Division of Environmental Protection, so long as source water quality remains within specified required limits for turbidity and coliform and an annual Watershed Control program update indicates the watershed is at low risk for pathogens.

The main concern that AIS present with regard to water supply is the tendency of quagga and zebra mussels to biofoul freshwater intake pipes. This invasion not only requires costly maintenance or periodic replacement of pipes, but it can result in the loss of filtration exemption due to the presence of mussels and plants in the water intake systems that raise human health concerns. Plants and invertebrates may colonize in large numbers near intakes, depositing organic contaminants into the water. If water suppliers cannot rely on the water drawn from the lake to be free of microbial contaminants then further purification infrastructure might be necessary, raising unit costs for suppliers, and ultimately consumers (TWSA 2007).

Table 12 provides estimates of the necessary infrastructure spending to maintain current production levels without sacrificing drinking water quality in the event of a serious mussel and plant infestation near, on, or in the intake system. The redundant intake system would allow suppliers to take intakes offline in rotation for cleaning and maintenance without interrupting service.

The presence of organic material in supply water can result in taste and odor problems that require another level of purification. In 1990, $1 million per million gallons per day (MGD) was estimated in capital costs for design and construction of tertiary treatment. The estimate includes a chlorine injection system to prevent mussels from colonizing the inside of intake pipes.

In total, a conservative infrastructure cost of approximately $25 million could be borne by the Region's water suppliers if invasive mussels infest the lake. The low and median estimates are presented in Table E-12. Operation and maintenance costs will contribute to this total. For example, according to the recommended chlorine levels for injection systems by the U.S. Army Corps of Engineer's Zebra Mussel Chemical Control Guide, Lake Tahoe Region suppliers as a whole will need to use about 147 pounds of liquid chlorine per day, or 27 tons per year (Sprecher and Getsinger 2000). At a price of around $500 per ton (City of Lewisville 2008), water suppliers would need to spend more than $250,000 per year on chlorine alone.

Table E-12. Estimated Water Supply Infrastructure Costs

Cost Category	$'08 Low	$'08 Median	Justification
Redundant Intake System	3,100,685	4,429,549	Continued operation while performing maintenance
Taste and Odor Control System	20,326,710	29,038,157	Maintains clean taste and odor
Chlorine Intake Injection System	252,000	360,000	Prevents mussel colonization on inside of intakes
Annual Cleaning and Maintenance	1,219,603	1,742,289	De-foul intakes on rotation and regular O&M
Annual Liquid Chlorine Supply	175,000	250,000	One year chemical supply cost
Total	**24,898,997**	**35,819,996**	

3.5 Maintenance Costs

In addition to increased water supply infrastructure maintenance costs identified above, AIS introduce a suite of general maintenance costs, including those associated with boats and piers. Boaters with jet boats or personal watercraft will require screens to filter plants and an annual flush to maintain their intake and cooling systems. In addition, fishing boats may need to be fit with a weedless propeller and trolling motor that allows them to navigate the plant-filled shallows without damaging the drive shaft of the boat's main engine (Bellows 2003).

Boats must also be thoroughly cleaned and inspected before being moved to another water body to reduce the possibility of further spreading AIS. Those boaters who could previously store their craft in the water for whole seasons may need to buy a boat hoist to avoid the damage done to hulls by mussels. When in the lake, boats may need to run the engine every few days to prevent mussels from colonizing the cooling system, resulting in large repair bills (Bellows 2003). Winter dry storage and winterization/activation will be mandatory to avoid mussel damage or if boats are permanently stored on the lake they may need a coat of biocide bottom paint to keep mussels from growing on the hull.

AIS also impact boaters and business owners who have private piers and docks. There are over 700 piers, around 20 docks, and about 4,400 buoys on Lake Tahoe (TRPA 2006). Piers may become non-functional to boats without weedless propellers if they are located in infested shallows. Piers may also degrade and wear more quickly as result of mussel biofouling penetrating the piles. Floating docks and buoys can be weighed down by mussel colonies and will require periodic cleaning, replacement, or reinforcement to remain functional (Indiana DNR 2005).

There are also costs to marinas to maintain their facilities and provide adequate service to their customers. Infestations of Eurasian watermilfoil and curlyleaf pondweed are extremely problematic in marinas around Lake Tahoe. Their impacts are most notable in the Tahoe Keys where aquatic weed harvesters are used continuously during the growing season. Tahoe Keys Marina spent about $260,000 in 2007 to mechanically harvest aquatic weeds from the Keys Lagoon (Harry Dotson, TKPOA, Personal Communication 2008). While not every marina is large enough to warrant use of harvesters, each will incur removal costs from aquatic weeds with AIS infestation. Smaller marinas will need to invest in physical methods such as benthic barriers or hand pulling to control infestations. Lakeside and Ski Run marinas actively control invasive aquatic plants by these physical methods.

The magnitude of these future maintenance costs are difficult to quantify because the financial impact is dependent on the severity of the AIS invasion and the precautions boat and business owners take. However, some costs do facilitate estimation based on existing data.

Through interviews of local marine service shops, estimation of AIS-induced additional expenses produced a range of $200 to $400, based on an approximation of at least two additional hours of labor time per year per vessel. The more conservative ($200 per vessel per year) value was applied for this analysis. The number of boats, 7,418, was estimated by assuming the number of slips and buoys from the Lake Tahoe 2004 Shorezone Ordinance EIS was representative of the number of boats permanently stored at Tahoe (TRPA 2004). This number likely underestimates the number of boats that use the lake regularly because it only includes resident boaters, providing a conservative estimation of impact. The estimate suggests that the annual additional maintenance costs to Lake Tahoe boaters may result in an additional AIS impact of $1,483,600 per year in 2008 prices.

In addition, there are additional costs that will be incurred for pier maintenance. As mentioned above, the functional life of a pier may be shortened due to AIS. The TRPA estimated that the piers on Lake Tahoe are worth between $18.5 million and $36.8 million depending on the assumed cost per square foot (TRPA 2004). Adjusted to 2008 dollars, piers are valued between $21.3 and $42.5 million. It is likely that AIS-induced damages would result in accelerated depreciation of the piers. It was assumed that AIS might cause advanced depreciation equivalent to 15 to 25% of the current value of piers. Referencing the conservative value from TRPA, and using the conservative percent reduction, this equates to about $4.3 million in losses.

4 Summary of Potential AIS Economic Impacts

The potential for economic loss at Lake Tahoe as a result of AIS infestation is high. Given Lake Tahoe's unique combination of outdoor recreation that draws in visitors and resort and gaming oriented entertainment that yields large tourism revenues, AIS has the potential to severely impact the economy in the Lake Tahoe Region.

To obtain an estimate of the potential combined impacts of AIS infestation at Lake Tahoe, each category of AIS damages described in Section 3 (Recreation, Tourism, Property Values, Water Supply, and Maintenance Costs) was evaluated over a fifty year period of analysis and the present value of each stream of AIS damage was calculated and converted to an average annual equivalent damage for comparison. Present value and amortization calculations were based upon the U.S. Government Fiscal Year 2008 Federal discount rate for water resources study of 4 $^{7}/_{8}$ % (USACE 2007).

The assumptions applied for estimating the 50 year stream of damages for each category are described in the following paragraphs. Table 13 provides a summary of the resultant present value and average annual damage calculations by category and in total.

4.1 RECREATION

In order to conservatively assess the present value of recreation over the period of analysis, the low to median lost recreation values from Table 6 were distributed over the 50 year period of analysis based on the assumption that damages grew from the low end of 2% to the median of 5% at a consistent rate over the period and the present value of the stream of damages was calculated in 2008 dollars. Based on these assumptions, the resultant present value of lost recreation value due to AIS in the Lake Tahoe Region over a 50 year period of analysis was estimated to be $32,594,000, with an associated average annual loss of $1,751,000.

4.2 TOURISM

The present value of lost tourism spending as a result of AIS was assessed using the same percent reductions as the recreation section. Low to median lost spending values from Table 8 were distributed over the 50 year period of analysis under the assumption that damages grew at a constant rate over the period in proportion to the diminished recreation visitation. Based on these assumptions, the present value of AIS-induced lost visitor spending in the Lake Tahoe Region over the 50 year period of analysis was estimated to be $156,576,000, with an average annual equivalent value of $8,412,000.

4.3 Property Values

Private lakeshore property at Lake Tahoe is very valuable and is the most susceptible to devaluation as a result of environmental degradation associated with AIS infestation. Table 11 summarizes the assessment of property values using reduction values from existing literature. For this summary section, the conservative reduction percentage of 5.4% was chosen. Because of the nature of real estate, evaluating a stream of losses in property value over a 50 year period is likely not representative of probable market reactions to AIS. It is more likely that property values will decline when AIS become well established and Lake Tahoe becomes known as an infested lake. Assessed property value reductions were assumed to take effect 10 years from now based upon time estimated for spread of AIS (most notably Eurasian watermilfoil) around the lake perimeter. Based on these assumptions, the present value of AIS impacts to property values for properties on Lake Tahoe is estimated to be $162,458,000 over the 50 year period of analysis with an average annual equivalent value of $8,728,000.

Additionally, reductions in property tax receipts by the surrounding jurisdictions will be associated with private property devaluation. Based upon 2007-2008 tax rates in the study area, property tax receipt reductions would range between $3.7 million and $13.8 million annually depending on the reduction scenario from Table 11. The lower conservative end of the range was selected at $3.7 million in annual tax receipt reductions. Assuming tax rates remain the same, the present value of these reductions over the 50 year period of analysis would be approximately $70 million.

4.4 Water Supply

Damages to water suppliers were assessed in terms of added infrastructure, operation, and maintenance costs that would be incurred in the event of mussel or plant infestations in and around the water intake locations. The infrastructure costs in Table E-12 were assessed at years 10, 30, and 50, implying initial construction in year 10 and a 20 year design life. Operation and maintenance costs were assessed annually, except in years where infrastructure was assessed. The conservative AIS-induced cost estimate from Section 4.4 was used to assess the damage stream. The conservative present value of AIS-induced damages to water suppliers over the 50 year period of analysis is estimated to be $37,243,000 with an average annual equivalent value of $2,001,000.

4.5 Maintenance Costs

Present value of AIS-induced added boat maintenance was assessed based on resident boats and the conservative estimate of $200 per year of additional maintenance cost for each vessel from Section 4.5. Based on these assumptions, the present value of boat damages from AIS over the 50 year period of analysis is estimated to be $27,616,000 with an average annual equivalent value of $1,484,000.

The value of AIS-induced damages to piers was assessed based on the assumption that depreciation would amount to between 15 and 20% of the 2008 value during year 25 of the 50 year period of analysis. Using the conservative estimate from TRPA and the 15%

value reduction, the resulting present value of the damage estimate, over the 50 year period of analysis, is $976,000. This is equivalent to an average annual payment of $52,000.

Table E-13. Summary of AIS Economic Impacts

Economic Impact Category	Present Value of 50 Year Stream of Damages[1]	Average Annual Damage[1]
Recreation	$32,594,000	$1,751,000
Tourism	$156,576,000	$8,412,000
Property Values[2]	$162,458,000	$8,728,000
Water Supply	$37,243,000	$2,001,000
Boats/Piers	$28,593,000	$1,536,000
Totals	**$417,462,000**	**$22,427,000**

Notes:
1. Present value and average annual cost calculations are based upon 2008 Federal discount rate for Water Resource Studies (4 7/8%) and a fifty year period of analysis. All values are presented in 2008 prices.
2. Does not include associated property tax reductions, estimated at a present value of $70 million, average annual value of $3.7 million.

5 AIS Management Costs

Resources in the Region are managed by multiple agencies with additional agencies and organizations providing funding and technical assistance. A complex matrix of these agencies has evolved with some agencies providing grant funding, others performing work with the funding, and others doing both. Many agencies are expending funds on AIS prevention, control, and research and that amount has escalated significantly in the last couple of years in the face of increasing threat of AIS impacts. To date, funding secured and allocated for spending on AIS prevention, control/eradication, research, monitoring, and education during the period of 2007 through 2009 amounts to around $5.2 million (Table E-14 and Figure E-1).

Table E-14. AIS Funding Awards and Sources from January 2007 to May 2009

Award Source	Award Amount
BOR	$550,000
IVGID	$20,000
LRWQCB	$100,000
LTSLT	$40,000
NDSL	$154,000
NLTLPF	$158,000
SNPLMA Rd 10	$985,000
SNPLMA Rd 8	$535,000
SNPLMA Rd 9	$620,000
TKPOA	$795,000
TRCD	$15,500
TRF	$50,000
TRPA	$160,000
USACE	$972,000
USACE - CTC	$70,000
USDA-ARS	$25,000
USFWS	$35,000
Grand Total	$5,284,500

Note: Awards rounded to nearest $1,000; See the main document's Acronyms and Abbreviations list (pg. iv) for the full name of the above agencies.

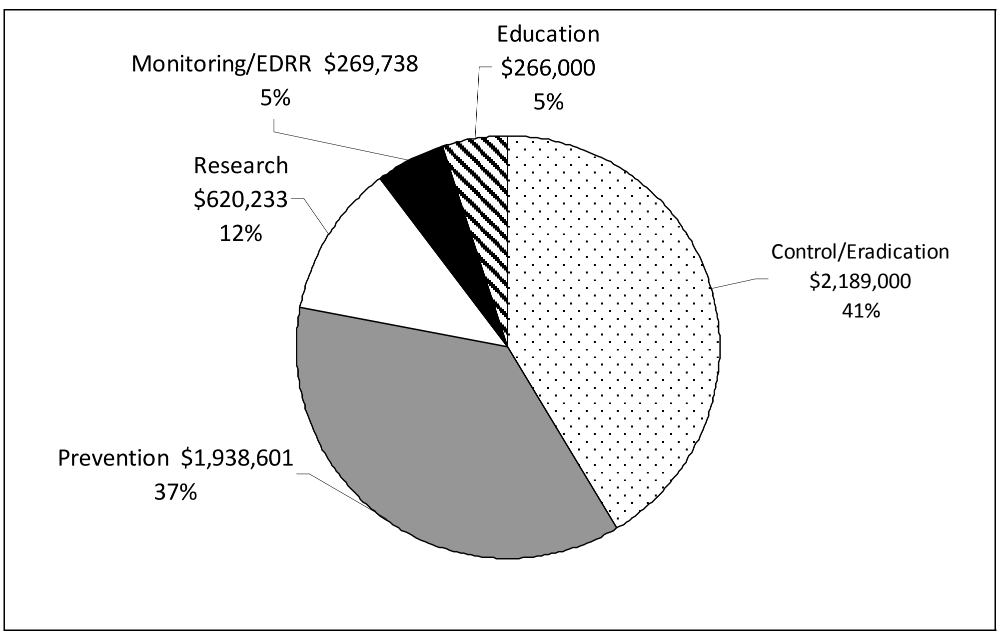

Figure E-1. AIS Funding by Task and Category from January 2007 to May 2009

If the AIS problem matures it will require greater resources. Agencies must adapt constantly, working not only to secure funding, but to hire new employees to carry out programs. For regions like Lake Tahoe, that have not yet experienced full scale infestations, prevention, early detection, education, and research, are a primary focus. Containment and control of existing AIS populations before they spread throughout the suitable habitats at the lake are another focus area.

The ability stakeholders to maintain and, if necessary, increase funding will be critical to effectively manage AIS at the lake. If the AIS problem grows quickly as it has done in other locales, these agencies will likely need to increase their AIS budgets accordingly.

Based upon the estimates in this study, the cost of preemptive spending on prevention, detection, and aggressive early control should be far less than the potential AIS damages inflicted on all facets of the Lake Tahoe Region. Existing literature was referenced to review benefit-cost ratio estimates from AIS work at other lakes around the country (OTA 1993, Rockwell 2003). Sampled benefit-cost ratios ranged from as low as 1:1 to as high as 300:1. Some studies point out that benefit to cost ratios decrease rapidly as you move from prevention to control to eradication (Leung et al. 2002). Based on a 20-year simulation model of the economic impacts of public investment in zebra mussel prevention and eradication in Lake Okeechobee, Florida, Lee et al. (2002) estimated the benefit to cost ratio of prevention to be 70:1; early eradication produced a lower ratio of 4.4:1, and late eradication yielded benefits of just 1.2:1. (Note: zebra mussels are not currently present in Lake Okeechobee). The wide ranges of values presented in other studies illustrate that each species and each lake is unique. Nevertheless, they also illustrate that maximum benefits are likely realized through early, preemptive action. From a financial perspective, success of prevention and detection hinges on the willingness of funding sources to invest substantially during this early phase of infestation.

6 Conclusions

The existing literature on Lake Tahoe Region concluded that outdoor recreation opportunities are the unique characteristic of the economy that allows the nearby resort and gaming oriented entertainment industry to prosper. The lake and the pristine natural environment have been found to be the primary draw for summer recreationists to the Lake Tahoe Region. This analysis of potential impacts of AIS infestation at Lake Tahoe found the combined losses of recreation visitation value and associated tourism spending to have the potential to reach over $189 million over a fifty year period of analysis (an average annual damage of $10.2 million). Adding private property value losses ($8.7 million in average annual losses), water supply infrastructure costs ($2.0 million in average annual losses), and boat and pier damages ($1.5 million in average annual damages) results in an estimated combined average damage of $22.4 million per year.

This economic analysis was based entirely on existing socioeconomic data for the study area, existing studies of AIS impacts at other sites, and professional judgment on the part of the study team. The results present a reasonable estimation of the potential economic impacts of unchecked AIS infestation at Lake Tahoe given available information. The report noted data gaps presented in the AIS literature addressing economic impacts. Research that would help to improve future analysis of AIS impacts at Lake Tahoe, include: research related to recreation visitation (specifically a methodology for converting existing visitor counts by various state and federal parks agencies into a consistent visitor-day count), Lake Tahoe specific recreation value, and expected changes in recreation visitation and value under various AIS infestation scenarios.

The demonstrated potential for significant economic impacts attests to the economic threat posed by AIS at the lake and should serve to inform policy decisions regarding the merits of committing limited funding to AIS detection, prevention and control in the Lake Tahoe Region.

The last two years have witnessed escalation of local, state, and federal agency spending on AIS management at Lake Tahoe. As of 2008, based on available data, the Lake Tahoe Region has secured around $5.2 million dollars for spending on AIS from 2007 through 2009. While a significant sum, professional experience suggests that this level will need to be sustained, if not increased, as the AIS problem at Lake Tahoe matures.

Previous research indicates the most cost effective strategies for AIS Management are those that focus on early prevention, detection and control before AIS populations become fully established. The findings of this economic study should inform development of the Lake Tahoe Region AIS Management Plan as well as future decision making regarding commitment of financial resources to AIS management in the Lake Tahoe Region.

7 Literature Cited

ANSTF (Aquatic Nuisance Species Task Force). 2008. Protect Your Waters: Stop Aquatic Hitchhikers: Impacts. Accessed 21 July 2008. http://www.protectyourwaters.net/impacts.php#a.

Ara, S., E. Irwin, and T. Haab. 2006. The Influence of Water Quality on the Housing Price around Lake Erie. Department of Agricultural, Environmental and Development Economics. Ohio State University. Accessed online at: http://ageconsearch.umn.edu/bitstream/21275/1/sp06ar05.pdf.

Bellows, A. 2003. Protect Your Boat and Engine From Zebra Mussels. Educational Material prepared for Wisconsin DNR. Accessed 21 July 2008. www.uwex.edu/erc/pdf/AI/ProtectYourBoat.pdf.

Berrum, B. 2008. Treasurer's Office Tax Rates, Bill Berrum, Washoe County Treasurer. Accessed 8 August 2008. http://www.washoecounty.us/treas/taxcalc.htm~printme=on.

BoatTahoe.com. 2008. The Complete Guide to Boating Lake Tahoe: Lake Tahoe Fish. Accessed 21 July 2008. http://www.boattahoe.com/tahoefish.htm.

Boyle, K. and R. Bouchard. 2003. "Water Quality Effects on Property Prices in Northern New England," LakeLine Vol 23(3). pp. 24-27. Maine Bureau of Land and Water

Quality: The Economics of Lakes - Dollars and $ense. Accessed online at: http://www.state.me.us/dep/blwq/doclake/research.htm#waterclarity.

City of Lewisville. 2008. Bid Tab 08-15-A: Water and Wastewater Chemicals. City of Lewisville, TX. http://www.cityoflewisville.com/wcmsite/publishing.nsf/AttachmentsByTitle/08-15-Abid+tab/$FILE/Bid+tab+08-15-A.pdf.

Coats, R., J. Perez-Losada, G. Schladow, R. Richards, and C. Goldman. 2006. The warming of Lake Tahoe. Climate Change. 76(1-2):1573-1480.

Dotson, H. Tahoe Keys Property Owners Association (TKPOA). 2008. Correspondence and Personal Communication regarding Tahoe Keys expenditures related to AIS.

Douglas County Assessor. 2008. How the Taxable Value of Property is Determined. Douglas County, Nevada. Accessed 8 August 2008. http://assessor.co.douglas.nv.us/howpropassessed.cfm

Eiswerth, M.E., S.G. Donaldson, and W.S. Johnson. 2000. Potential environmental impacts and economic damages of Eurasian watermilfoil in Western Nevada and Northern California. Weed Technology. 14(3):511-518.

Fisk, D.L., R.A. Rowntree, T.A. Cahill, C.R. Goldman, G. Gruell, R. Harris, D. Leisz, S. Lindstrom, R. Kattlemann, D. Machida, R. Lacey, P. Rucks, D.A. Sharkey, and D.S. Ziegler. 1996. Lake Tahoe case study. In: Status of the Sierra Nevada. Addendum. Sierra Nevada Ecosystem Restoration Project. Final Report to Congress. Wildland Resources Center Report No. 38. University of California, Davis, California.

Gibbs, J.P., J.M. Halstead, K.J. Boyle, and J. Huang. 2002. A Hedonic Analysis of the Effects of Lake Water Clarity on New Hampshire Lakefront Properties. Scientific Contribution No. 2064 of the New Hampshire Agricultural Experiment Station. Northeastern Agricultural and Resource Economics Association. http://findarticles.com/p/articles/mi_qa4046/is_200204/ai_n9052911/print?tag=artBody;col1.

Goldman, C. 1988. Primary production, nutrients, and transparency during the early onset of eutrophication in ultra-oligotrophic Lake Tahoe, California-Nevada. Limnology and Oceanography. 33(6 part 1):1321-1333.

Hagler-Bailly. 1999. Chapter 2: Estimates of Total Recreational Watercraft Use For the Lakes of Tahoe: Final Report. Obtained from TERC – Tahoe Environmental Research Center.

Halstead, J.M., J. Michaud, S. Hallas-Burt, J.P. Gibbs. 2003. Hedonic analysis of effects of nonnative invader species (*Myriophyllum heterophyllum*) on New Hampshire (USA) lakefront properties. Environmental Management. 32(3):391-398.

Horsch, E.J. 2008. Quantifying the Economic Effects of Invasive Species: A Non-Market Valuation Analysis of Eurasian Watermilfoil. Unpublished Master's Thesis, Dept. of Agricultural and Applied Economics, University of Wisconsin, Madison.

Indiana DNR. State of Indiana Department of Natural Resources. 2005. Aquatic Invasive Species: Zebra Mussels: Fact Sheet. Accessed 22 July 2008. http://www.in.gov/dnr/files/ZEBRA-MUSSEL.pdf.

Jassby, A.D., C.R. Goldman, J.E. Reuter, R.C. Richards, and A.C. Heyvaert. 2001. Lake Tahoe: diagnosis and rehabilitation of a large mountain lake. *In*: M. Munawar and R.E. Hecky (Eds.). The Great Lakes of the World (GLOW): Food-web, Health, and Integrity. Leiden (The Netherlands). Backhuys. 431-454 pp.

Krysel, C., E.M. Boyer, C. Parson, and P. Welle. 2003. Lakeshore Property Values and Water Quality: Evidence from Property Sales in the Mississippi Headwaters Region. Bemidji State University.

Lee, D.J., D.C. Adams, and F.J. Rossi. 2007. The Economic Impact of Zebra Mussels in Florida. University of Florida IFAS Extension. Accessed 5 August 2008. http://edis.ifas.ufl.edu/FE693.

Leung, B., D.M. Lodge, D. Finoff, J.F. Shrogen, M.A. Lewis, and G. Lamberti. 2002. An ounce of prevention or a pound of cure: bioeconomic risk analysis of invasive species. The Royal Society. 269:2407-2413.

Lodge, D., and D. Finnoff. 2008. Invasive Species in the Great Lakes: Costing Us Our Future: Annual Losses to Great Lakes Region by Ship-borne Invasive Species at least $200 Million. Preliminary Results.

Lovell, S.J. and S.F. Stone. 2005. The Economic Impacts of Aquatic Invasive Species: A Review of the Literature. US EPA, National Center for Environmental Economics, 1200 Pennsylvania Ave, NW (MC 1809), Washington DC 20460.

LTVA (Lake Tahoe Visitors Authority). 2008. Lake Tahoe History. Accessed 8 July 2008. http://www.bluelaketahoe.com/page.php?p=history&l=1.

Michigan Sea Grant. 2007. Aquatic Invasive Species: Mollusks: Quagga/Zebra Mussel Fact Sheet. Accessed 23 July 2008. http://www.miseagrant.umich.edu/ais/mussels.html

Montgomery, R. 2007. Summer Bass Fishing Guntersville Lake. Accessed 23 July 23 2008. http://www.fishin.com/articles/alabamaarticles/gunthersumfish.htm

Nechodom, M., R. Rowntree, N. Dennis, H. Robison, and J. Goldstein. 1999. Chapter Six: Social, Economic, and Institutional Assessment. Lake Tahoe Watershed Assessment. For the United States Dept. of Agriculture Forest Service. In collaboration with USDA-Pacific Southwest Region and Research Station, the Tahoe Regional Planning Agency, the University of California at Davis, the University of Nevada at Reno, and the Desert Research Institute, Reno, Nevada. Available online at: http://www.fs.fed.us/psw/publications/documents/gtr-175/

Nozicka, C. 2001. Recreation User Preference Survey and Focus Group Research: Final Report.

Nozicka, C. 2003. Future Recreation Conditions and Facilities Survey: Final Report.

NSBDC (Nevada Small Business Development Center). 2008. Total Increases in Population 2005 to 2026. Accessed 7 July 2008. http://www.nsbdc.org/what/data_statistics/demographer/pubs/estimates/.

NTA (Nevada Taxpayers Association). 2005. Understanding Nevada's Property Tax System Brochure. Carson City, NV & Las Vegas, NV.

OTA (Office of Technology Assessment). 1993. Harmful Non-Indigenous Species in the United States, OTA-F-565. Washington, DC: U.S. Government Printing Office. www.anstaskforce.gov/Documents/OTA_Report_1993.pdf

Padilla, D.K., M.A. Chotkowski, and L.A.J. Buchan. 1996. Predicting the spread of zebra mussels (*Dreissena polymorpha*) to inland waters using boater movement. Global Ecology and Biogeography Letters. 5(6):353-359.

Pimentel, D., R. Zuniga, and D. Morrison. 2004. Update on the Environmental and Economic Costs Associated with Alien-invasive Species in the United States. College of Agriculture and Life Sciences, Cornell University, Ithaca, NY.

Placer County. 2008. Property Tax Information. Placer County, California. Accessed 8 August 2008. http://www.placer.ca.gov/Departments/Auditor/property_tax.aspx

Rockwell, Jr., W.H. 2003. Summary of a Survey of the Literature on the Economic Impact of Aquatic Weeds. Aquatic Ecosystem Restoration Foundation. Accessed 8 Aug 2008. http://www.aquatics.org/pubs/economic_impact.pdf

Rosenberger, R.S. and J.B. Loomis. 2001. Benefit Transfer of Outdoor Recreation Use Values: A Technical Document Supporting the Forest Service Strategic Plan (2000 revision). Gen. Tech. Rep. RMRS-GTR-72. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 59:3.

Sprecher, S.L. and K.D. Getsinger. 2000. Zebra Mussel Research Program: Zebra Mussel Chemical Control Guide. Environmental Laboratory. ERDC/EL TR-00-1. US Army Corps of Engineers, Engineer Research and Development Center.

State of California. 2007. Population Projections for California and Its Counties 2000-2050. State of California, Department of Finance. Sacramento, California. Accessed 8 July 2008. http://www.dof.ca.gov/html/DEMOGRAP/ReportsPapers/Projections/P1/P1.php.

Strategic Marketing Group. 1998. Consumer Insights Visitor Profile – Quarter 3, 1998. Prepared for the Lake Tahoe Visitors Authority. South Lake Tahoe, California.

Stynes, D.J. 2006. National Park Visitor Spending and Payroll Impacts. National Park Service Social Science Program. Michigan State University. http://web4.canr.msu.edu/mgm2/parks/NPSSystem2006.pdf

Tahoe Water Supplier Association (TWSA). 2007. Sanitary Survey and Watershed Control Program Update.

TCSF (Tahoe Center for a Sustainable Future). 1996. 1996/1997 Annual Review and Strategic Direction. http://ceres.ca.gov/tcsf/

TRCD (Tahoe Resource Conservation District). 2007. About TRCD: Funding. Tahoe Resource Conservation District. Accessed 24 July 2008. http://www.tahoercd.org/funding.php

TRPA (Tahoe Regional Planning Agency). 2002. TRPA 2001 Threshold Evaluation.

TRPA (Tahoe Regional Planning Agency). 2006. Lake Tahoe Shorezone Ordinance Amendments Final EIS from November 2006. http://www.trpa.org/default.aspx?tabid=126

TRPA (Tahoe Regional Planning Agency). 2007. Environmental Improvement Program Progress Report 2007. Accessed 9 July 2008. http://www.trpa.org/documents/docdwnlds/EIP/EIPBook_FINAL_54-76.pdf.

TRPA (Tahoe Regional Planning Agency). 2004. 2004 Lake Tahoe Shorezone Ordinance Amendments Draft EIS: Chapter 14: Economics.

USACE (U.S. Army Corps of Engineers). 2007. CECW-CP: Economic Guidance Memoranda, 08-01, Federal Interest Rates for of Engineers Project for Fiscal Year 2008. U.S. Army Corps of Engineers, Department of the Army, Washington D.C. http://www.usace.army.mil/CECW/PlanningCOP/Documents/egms/egm08_01.pdf

United States Census Bureau. 1990. 1990 Census. http://factfinder.census.gov/. Accessed 7 July 2008.

United States Census Bureau. 2000. 2007 Population Estimates Program. 2000 Census. 1990 Census. Accessed 7 July 2008. http://factfinder.census.gov,

USEPA (United States Environmental Protection Agency). 2008. Detroit River - Western Lake Erie Basin Indicator Project: Water Clarity in Western Lake Erie. Assessed 15 December 2008. http://www.epa.gov/med/grosseile_site/indicators/water-clarity.html#fig1

USFS (United States Forest Service). 2006. National Visitor Use Monitoring Program for Tahoe Lake Basin Management Unit. Accessed 10 July 10 2008. http://www.fs.fed.us/recreation/programs/nvum/reports/year5/ltbmu.htm#_Toc148257775.

Zutter, S. 2008. Property Tax Division: El Dorado County, California. Accessed 8 August 2008. http://www.co.el-dorado.ca.us/auditor-controller/PT_Index.html

Appendix F: AIS of Concern

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1 Introduction

This Appendix provides a summary of life histories, invasive life strategies, and environmental requirements for select AIS of concern in the Region, including aquatic plants, warm water fishes, and other species such as invertebrates. These species are either present in the Region or threatening introduction. The rationale for inclusion in this list was based on species 1) that are established in the Region with a high potential for spreading within Lake Tahoe or other in-Region waterbodies, 2) whose introduction would cause irreversible damage to the ecological, economic, or human health within the Region, 3) for which there is no operational means of controlling, or 4) for which prevention or control costs are reasonable. Future Plan revisions should include an evaluation of this summary and consider the addition or subtraction of species, as needed. Included in this summary are the following species:

- Eurasian watermilfoil
- Curlyleaf pondweed
- Largemouth and Smallmouth bass
- Bluegill
- Brown bullhead
- Crappie
- Asian clam
- Quagga and zebra mussel
- New Zealand mudsnail
- Signal crayfish

2 Aquatic Plants

The following sections provide discussions about life histories, reproductive strategies, and environmental requirements for aquatic plants currently in the Region.

2.1 Eurasian Watermilfoil (*Myriophyllum spicatum*)

Life history

Eurasian watermilfoil is a submersed perennial herb native to Europe, Asia, and Northern Africa and has become naturalized in North America, tropical South America, and Southern Africa (USGS 2008). Reproduction occurs by seed but more readily through the establishment of stem fragments or stolons (Smith and Barko 1990, Madsen et al. 1998). Seed production is more common in eutrophic rather than oligotrophic waters (Madsen and Boylen 1989). Stem fragments produce natural abscission points, called autofragments that are associated with the end of the growing season (Smith and Barko 1990) and with flowering and seed set (Madsen 1997). Conversely, allofragments are fragments produced by mechanical means such as boat propellers or mechanical harvesting. Eurasian watermilfoil is easily confused with the native Northern watermilfoil (*Myriophyllum sibericum*). A hybrid between the two has been documented in North America (Moody and Les 2007) and the management implications of this hybrid are still unknown.

Invasive life strategies

Stem fragments are the primary propagule for the spread of Eurasian watermilfoil (Smith and Barko 1990) which can overtake a waterbody (Boylen et al. 1999). Mechanical control activities can exacerbate the spread by releasing viable stem fragments into the environment (Carpenter 1980). Human activities such as transporting contaminated boats between waterbodies, are a common method of dispersal (Smith and Barko 1990).

Environmental requirements

Eurasian watermilfoil is tolerant of low water temperature and capable of over-wintering while maintaining a dense canopy (Madsen et al. 1991). Rapid spring growth from stem fragments occurs when water temperature reaches about 15°C (Smith and Barko 1990). Optimum plant growth is observed on inorganic sediments of fine-texture and intermediate density (Smith and Barko 1990) or between 10 to 25% organic matter (summarized in Nichols and Shaw 1986).

2.2 CURLYLEAF PONDWEED (*POTAMOGETON CRISPUS*)

Life history

Curlyleaf pondweed is native to Eurasia, Africa, and Australia but is now found across the U.S. (USDA-NRCS 2008) in freshwater lakes, ponds, rivers, and slightly brackish waters (GISD 2008). Similar to Eurasian watermilfoil, curlyleaf pondweed impacts waterbodies by impeding aquatic recreation and navigation, particularly during the spring and summer.

Curlyleaf pondweed is a submersed and rooted perennial that spreads and overwinters primarily by vegetative structures such as rhizomes, stem fragments, and turions (Sastroutomo 1981, Brayshaw 2000). Within most of the species range, peak biomass is reached in late spring to early summer when turions are formed. During late summer, the plant senesces leaving behind fruits and turions, mimicking an annual life history (Netherland et al. 2000). It is only during this time of the year that curlyleaf pondweed does not outcompete neighboring plants. In some regions, turions germinate in the fall and grow slowly through the winter months until spring when rapid growth begins (Sastroutomo 1981). Turions can overwinter under the ice, followed by rapid spring growth.

Invasive life strategies

The diversity of curlyleaf pondweed propagation methods provides a near year round capacity for this species to spread. Rapid early spring growth from turions provides a competitive advantage over native species that require warmer water to sprout from seed or vegetative structures (Bouldan et al. 1994). Turions formed during early summer (before plant senescence) are easily transported on water currents, expanding the infestation.

Environmental requirements

The most rapid growth rates are reported to occur at water temperatures between 5°C and 20°C (Bouldan et al. 1994) and stems, turions, and rhizomes can persist under ice. The typical pH range is 6.4 to 8.5 (USDA-NRCS 2008) and curlyleaf is commonly found rooted in soft, organic substrates (Bolduan et al. 1994). Plants can grow to 12 m in height with sufficient light (Sheldon and Boylen 1977) or to a depth where about 21% of the surface irradiance is available (Chambers and Kalff 1985).

3 Warm Water Fishes

The following sections provide discussions about life histories, reproductive strategies, and environmental requirements for some warm water fished currently in the Region or threatening introduction.

3.1 Largemouth and Smallmouth Bass (*Micropterus salmoides* and *M. dolomieui*)

Largemouth bass are native to North America, from the Great Lake and Hudson Bay, down through the Mississippi River drainage and the Atlantic drainages from North Carolina and Florida to northern Mexico (Page and Burr 1991). Smallmouth bass share a similar habitat range with largemouth bass except smallmouth tends to prefer cooler rivers and lakes (Berra 2001). Both species have been widely introduced as a sport fish. In Lake Tahoe, largemouth bass are present, particularly in the Tahoe Keys (Kamerath et al. 2008). Smallmouth bass are not present in Lake Tahoe but do occur in the Truckee River near the confluence with the Little Truckee River (Kim Tisdale, NDOW, personal communication, February 26, 2009).

Life history

The life histories of small- and largemouth bass are very similar and will be discussed together unless otherwise noted. Smallmouth bass spawn in the spring from March to June when water temperatures range between 12.8 and 22°C (Scott and Crossman 1973, Baylis et al. 1993). Largemouth bass also spawn in the spring from about March to August or when water temperatures reach 15°C (Scott and Crossman 1973).

Male largemouth bass construct nests on shallow muddy bottoms, many times near plants, while male smallmouth bass prefer areas with hard substrates such as sand or gravel. Males of both species avidly defend their nest site (Scott and Crossman 1973). Bass use various submersed structures to hide (e.g., vegetation, wood, and docks). Similar to bluegill, largemouth bass are associated with the dense submersed vegetation found in the Tahoe Keys and at the mouth of Taylor Creek (Kamerath 2008, Chandra et al. 2009).

Adult bass are piscivorous and are effective at ambushing and feeding on other fishes, crayfish, and frogs while juveniles feed on crustaceans, other small fishes, and insects (Page and Burr 1991). The diet of largemouth bass found in Lake Tahoe was investigated in 2006 to 2008. Chandra et al. (2009) found shifts in diet between age groups (based on fish length) and seasons. Diets of largemouth bass ranging in size from 4.0 to 8.1 cm were comprised primarily of zooplankton (48.6%); however, diets shifted to piscivory in bass ranging in size from 8.1 to 12.0 cm. Also observed were Decapoda (in bass greater than 8.0 cm) and Mollusca. Seasonally, invertebrates were the most common diet items in May and June 2006, plant, fish, and Mollusca were most common in May and October 2006, and fish were found in the diet only during August and October 2006. Though not present in Lake Tahoe, it is known that juvenile smallmouth bass feed exclusively on aquatic insects and plankton while adults target a wider array of prey species such as crayfish, other fishes, and aquatic, benthic, and terrestrial insects (Scott and Crossman 1973, Waters et al. 1993).

Environmental requirements

Smallmouth bass are more commonly found in cooler waters and can thrive at lower temperatures (McGinnis 1984) than largemouth bass. Largemouth bass are found in clear, vegetated quiescent waterbodies (Page and Burr 1991). Smallmouth bass prefer rocky and sandy areas of large clear lakes, streams, and rivers in moderately shallow water (Sigler and Sigler 1987). They are associated with cover such as rock, shoals or submerged logs and they do not associate with dense aquatic vegetation to the same degree as largemouth bass. Both require neutral pH (7 to 7.5) (Page and Burr 1991). Smallmouth bass are not presently found in the Tahoe Region; however, environmental conditions would likely support a reproducing population if an illegal introduction were to occur.

3.2 Bluegill (*Lepomis macrochirus*)

Bluegill is a common forage fish for large- and smallmouth bass and is routinely stocked together for managed warm water fisheries. Kamerath et al (2008) suggests there is strong competition between bluegill and native fish for food resources. Data also suggests that the presences of bluegill can facilitate increases in non-native bullfrog populations through predator suppression because bluegill prey on dragonflies which prey on bullfrog tadpoles (Adams et al. 2003).

Life history

Female bluegills reach sexual maturity about 7.5 cm in length and typically spawn in about 2.5 to 13 cm of water in circular nests constructed and guarded by males (Higginbotham 1988, Werner et al. 1996). In California, spawning usually occurs between April and June or when the nearshore water temperature reaches 20°C (McGinnis 1984). Following hatching, juveniles migrate to the limnetic zone for approximately one month to feed (primarily on zooplankton) and grow before returning to the nearshore environment to mature (Werner et al. 1996). In addition to zooplankton, adult bluegills also consume aquatic insects and the eggs of other fishes including largemouth bass (Turner 1966, McGinnis 1984, Kamerath et al. 2008). Shifts between littoral and pelagic feeding during the bluegill life cycle may be an adaptation to escape predation by largemouth bass (Werner and Hall 1988). Chandra et al. (2009) found that bluegill diet exhibits substantial “breadth” and “plasticity” in novel environments such as Lake Tahoe. For example, all size classes consume zooplankton, Mollusca, plant material, and invertebrates. Seasonally, gastropods and plant material is dominant in the bluegill diet in October and May, aquatic invertebrates in June and August, and Mollusca was the high proportion in all sizes classes in all months.

Invasive life strategies

Bluegill can produce up to 50,000 eggs per female, per spawning cycle, and males actively defend both nests and fry (McGinnis 1984). These traits alone are largely responsible for allowing this species to quickly colonize available habitat.

Environmental requirements

Bluegill prefer near shore habitat with aquatic vegetation or woody debris for cover in clear water over a sandy substrate (Moyle and Nichols 1973; Higginbotham 1988; Page and Burr 1991; Chandra et al. 2009). The minimum spawning temperature for bluegill is estimated at 18°C (Moyle 1976) and preferred water pH ranges between 7.0 and 7.5 (Page and Burr 1991). In the Tahoe Keys, bluegill are associated with stands of Eurasian watermilfoil and curlyleaf pondweed where they provide cover from nearshore predators and refugia for invertebrates that serve as bluegill food sources (Richardson et al. 1998).

3.3 BROWN BULLHEAD (*AMEIURUS NEBULOSUS*)

Brown bullhead is native to the southern and eastern U.S. and has been introduced to 10 western states (Fuller et al. 1999) as a popular game fish. This may have been the means or reason of introduction into Lake Tahoe. The impacts of brown bullhead have not been fully documented and are largely unknown (Chadderton 2003).

Life history

Spawning occurs in nests that are built and cared for by both males and females (Scott and Crossman 1973). Eggs hatch in about one week and maturity is reached at two to three years or when the fish reach between 18 and 20 cm in length (McDowall 1990). Adult bullhead are nocturnal, opportunistic generalists that feed on detritus, mollusks, insects, leeches, crayfish, plankton, worms, algae, plant, fish eggs and various small fish, including lake trout (Turner 1966, Scott and Crossman 1973, McDowall 1990, Barnes and Hicks 2003). Juveniles feed on chironomid larvae, amphipods, and cladocerans (Scott and Crossman 1973).

Environmental requirements

Brown bullhead are found in pools, lakes, lagoons, ponds, and sluggish creeks and rivers. Weed beds provide preferential habitat (Barnes and Hicks 2003). In Lake Taupo (North Island, New Zealand), this species was found at depths between 0 to 17 m deep (Dedual 2002). Bullheads are tolerant of temperatures up 36°C, high carbon dioxide concentrations, and dissolved oxygen concentrations as low as 0.2 ppm (Scott and Crossman 1973).

3.4 BLACK AND WHITE CRAPPIE (*POMOXIS NITROMACULATUS* AND *P. ANNULARIS*)

Black crappie are native to North America, however, they were so widely introduced throughout the U.S. that their native range is difficult to determine (Scott and Crossman 1973). Presumably they are native to the Mississippi watershed and eastern North America, and not present along the Atlantic Coast north of the Carolinas. Black crappie have been present in Lake Tahoe since the late 1980s however, white crappie are not currently known to the Region.

Life history

Crappie have very high reproductive potential with up to 200,000 eggs per female per spawning (McGinnis 1984). Crappie spawn in spring and summer and eggs hatch in about 2-5 days. Males guard the eggs and hatchlings and individuals become sexually mature in the 2nd or 3rd year (Moyle 1976). Crappie feed from midnight to early morning (Scott and Crossman 1973). Individuals up to 16 cm feed on planktonic crustaceans and free-swimming, nocturnal, and dipterous larvae; larger individuals feed on small fishes, usually in localized schools near submerged objects.

Environmental requirements

Crappie are found in lakes, ponds, sloughs, and backwaters and pools of streams. They usually occur among vegetation over mud or sand, and are most common in clear water, particularly black crappie. The black crappie prefers waters that are clearer and cooler than those inhabited by the white crappie (PFBC 2000). The current threats to Lake Tahoe's water clarity may create suitable habitat for white crappie, increasing the risk of its population taking hold after an intentional or unintentional introduction.

4 Other Species

The following sections provide discussions about life histories, reproductive strategies, and environmental requirements for some other species currently in the Region or threatening introduction.

4.1 Asian Clam (*Corbicula fluminea*)

The Asian clam is native to temperate and tropical climates - Australia, southern Asia (e.g., Philippines), and the eastern Mediterranean. It was first collected along the banks of the Columbia River, Washington State in 1938 and since spread across temperate regions of the U.S. It is thought to have been introduced as live bait and by transport in ship ballast water. The spread of the Asian clam may be attributed to recreational pursuits by lodging in crevices of boat hulls, motors, and fishing gear (boots and waders commonly used by fishermen) and by supplementation programs associated with aquaculture. Asian clam are present in Lake Tahoe.

Life history

The Asian clam is hermaphroditic (i.e., capable of self-fertilization) and is a prolific spawner, releasing thousands of larvae per day (Balcom 1994). The larvae are released through the excurrent siphon, or an opening that pumps water and wastes out of the body of the clam. Spawning can occur continuously when water temperatures are above 16^{o}C but can be limited by seasonal temperature patterns. Cooler water such as that is found in the Connecticut River hosts only limited spawning of Asian clams from July through September (Balcom 1994). These low temperatures, however, sustain eggs and sperm in a dormant phase within reproductive tissues and commence spawning once environmental conditions become favorable. The lifespan of an Asian clam averages between two to four years with a maximum longevity of seven years (Aguirre and Poss 1999).

Invasive life strategies

Both fecundity in individual gravid clams and survival rate for juveniles is high for Asian clams, a combination that enables rapid colonization in localized areas. Additionally, during a short pelagic period, currents can disperse young larvae long distances (e.g., during high wind), allowing for increased in-lake movement.

Environmental requirements

Asian clams can be found in low numbers on almost any substrate but prefer fine clean sand, clay, or coarse sand (Belanger et al. 1985). The current success of Asian clams in select locations of Lake Tahoe may be due to the availability of clean sand along portions of the shoreline and the presence of a nearshore food base; organic particulates suspended in the water column. They are found on a variety of substrates in freshwater and even in some brackish water (Morton and Tong 1985, King et al. 1986), tolerating salinities up to 13 parts per thousand (Aguirre and Poss 1999). Substrate preferences for inhabitation include a large range in lakes and streams: silt, mud, sand, and gravel. Some known environmental thresholds are listed in Table F-1. Asian clams have reportedly survived in water with calcium levels as low as 4 to 5 mg L-1 and thrive in water with pH > 6.5 (cited in Wittmann et al. 2008 with reference to Bob McMahon). Asian clams have been found in water temperatures as low as 0 to 2°C but temperatures at least 16°C are required for veliger release (Hall 1984) with upper tolerances between 24°C and 34°C (Mattice and Dye 1976). Clam beds are discontinuous in nature and research is needed to understand factors that control their distribution. Limitations for invasion may be based on physical factors such as substrate, water temperature, wind, food source, and bathymetric pattern. Asian clam can survive very low levels of dissolved oxygen in the environment ranging from 1.0 to 3.0 (mg L^{-1}) (Sprung 1987). Signal crayfish are the least hardy of these species, only being able to survive in waters with dissolved oxygen concentrations of more than 9.09 (mg L^{-1}) (Usio et al. 2005).

4.2 Quagga and Zebra Mussels (*Dreissena bugensis* and *D. polymorpha*)

Zebra mussels are native to rivers in the Black and Caspian Sea region of Europe and were introduced to North America sometime between 1986 and 1988 (May and Marsden 1992). Quagga mussels are indigenous to the Dneiper River drainage of the Ukraine and were first sighted in the U.S. in 1989 (Mills et al. 1996). The Laurentian Great Lakes was the initial location for introduction of both dreissenid mussel species from ballast water in ocean-going vessels. Both species have since advanced through large rivers and lakes south and westward across the U.S. (Figure F-1). Zebra mussels are known to have their greatest effect on the ecology a waterbody and man-made infrastructure three to eight years after invasion, requiring time to maximize their abundance and spread (Ron Griffiths, OSU, personal communication, May 26, 2009). After adjusting to the local ecology (e.g., filtered phytoplankton to very low levels), zebra mussel populations collapse and individual size declines.

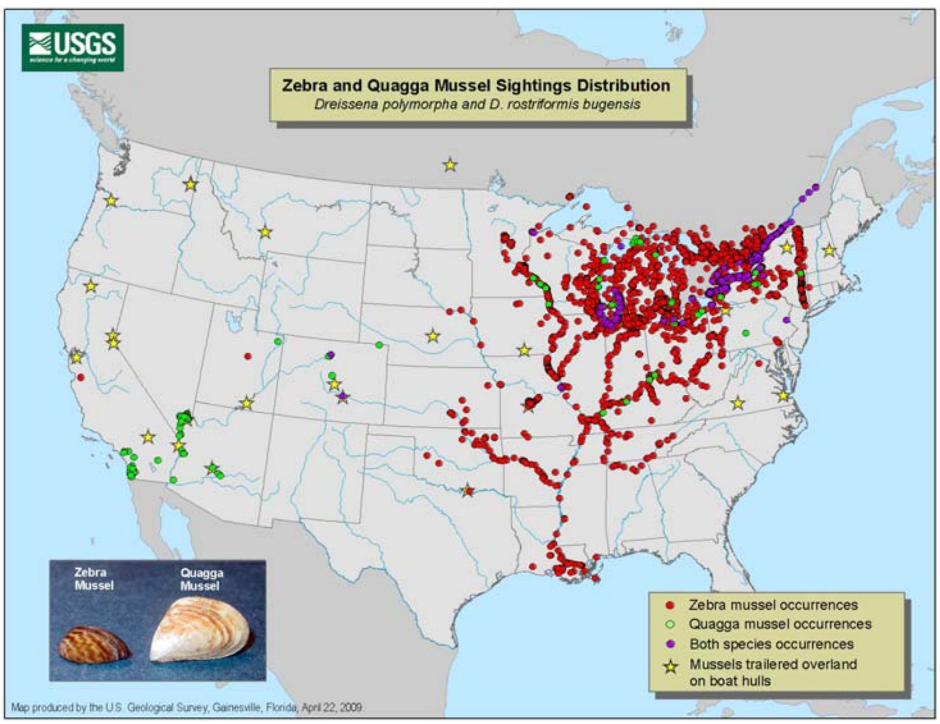

Figure F-1. U.S. distribution of quagga and zebra mussels (http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel. Accessed February 23, 2009)

Life history

Female dreissenid mussels release up to one million eggs per spawning season and three to five days after fertilization, free-swimming larvae (called veligers) emerge and have the potential to disperse widely through water currents, bilge water, ballast water, or in other wet areas on watercraft. Veligers typically feed from the food-rich photic zone (Johnson and Carlton 1996). The abundance of larvae can vary widely and is largely determined by physical environmental factors such as wind, wave action, and current (Claxton and Mackie 1998). The juvenile dreissenid life stage is characterized by settling onto hard substrates such as rocks, cables, and even other organisms such as clams and macrophytes and then anchoring themselves with byssal threads. This is the most vulnerable life stage for these organisms because settlement on suitable substrates is critical for development to maturity. For example, when dreissenid mussels settle and attach to plant material, they can often become dislodged when fragments break off of the plant. The ability to stay attached to substrates has been shown to be strongly correlated to the stability of the population, e.g., perennial plants maintain larger populations than annual plants (Stanczykowska and Lewandowski 1993). Even after attachment to a substrate; however, both juveniles and adults can move over short distances by attaching byssal threads at their leading edge while detaching byssal threads at their trailing edge.

Invasive life strategies

Dreissenid mussels are capable of dispersing during all life cycle stages (veliger, juvenile, and adult). The veliger and juvenile stages can easily be transported by biological vectors such as birds, turtles, and crayfish (Cohen 2007) and by humans through watercraft, bait buckets, and live wells. Adult mussels can survive remarkably long periods of time out of water under the right conditions (i.e., temperature and humidity). This capability facilitates their long distance transport between waterbodies. Additionally, adult and juvenile zebra mussels are readily transported by entangling in macrophytes on boat trailers (Johnson et al. 2001).

Environmental requirements

It is thought that North American populations of dreissenid mussels thrive in conditions similar to the southern-most limits of the European populations (USGS 2008); however, the response of dreissenid mussels varies between North American and European populations and even between western and eastern U.S. populations. Key environmental thresholds for dreissenid mussels include temperature, relative humidity, calcium, dissolved oxygen, pH, and food availability (summarized in Table 1). In general, dreissenid mussels require water temperatures to be within the range of 6°C (Karatayev et al. 1998) to 33°C (Cohen 2005) for optimal growth and development. Zebra mussel spawning occurs in the water column during the spring when the water temperature reaches around 12 to 16°C (Claudi and Mackie 1994; USGS 2008) but can occur at higher temperatures (18 to 23^{o}C) as has been documented in Lake Erie (Garton and Haag 1993). Quagga mussels spawn in lower water temperatures (5 to 9°C) also during the spring (Roe and MacIsaac 1997; Claxton and Mackie 1998).

Filtration rates increase in water temperatures from 5° to 10°C with declines occurring above 20°C (USGS 2008). The tolerance of dreissenid mussels to pH concentration gradients are mostly unknown though it is thought that the optimal pH range required for zebra mussel life history stages range between 7.4 and 9.4.

The dissolved oxygen requirements of dreissenid mussels varying widely, depending on life stage (Table F-1). Zebra mussel larvae can survive short periods at 18°C with dissolved oxygen at 20% of saturation (about 2 ppm) (Baker et al. 1993). Adults have been reported to need 25% saturation (between 3 and 2 ppm at 10° to 25°C) (Karatayev et al. 1998). Zebra mussels, however, have been found in high densities in areas with oxygen concentration levels as low as 3.2 ppm (Kraft 1994) but may be limited near 4 to 6 ppm (Doll 1997; Sorba and Williamson 1997; Cohen and Weinstein 1998; see Cohen 2007). Little information on quagga mussels oxygen limits is available in the literature (see Cohen 2007) leaving the assumption that they may have similar limits as zebra mussels. Despite this, McMahon (1996) suggests that quagga mussels may be more tolerant of hypoxic conditions than zebra mussels because of their ability to be more effective colonizers of hypolimnetic waters. Based on the above information, Cohen (2007) placed a limiting dissolved oxygen value of 4 ppm on both zebra and quagga mussels. The appearance that quagga mussels are more cold water tolerant than zebra mussels may, however, be confounded by other factors such as oxygen concentrations or food availability at depths with lower temperatures (Cohen 2007).

Table F-1. Factors Affecting the Survivability of Invasive Aquatic Invertebrates

Species or Environment		Temperature Minimum (°C)	Temperature Maximum (°C)	Desiccation (Relative Humidity)	Calcium Minimum (mg L^{-1})a	Dissolved Oxygen	pH	Food Preference
Zebra mussel	Larvae	12 [g]	25 [gg]		20 [e] – 24 [d]	20% or 2 ppm [f]	7.4 – 9.5 [i]	Phytoplankton [hh]
	Veliger	10 [ii]	25 [gg]		20 [e] – 24 [d]	≥ 2.0 mg L^{-1} (survival) [a]	7.4 – 9.5 [i]	Phytoplankton [hh]
	Adult	6 [ff]	26 – 33 [p]	15°C, between <5 & >95% RH [j]	8.3 – 32 [jj, e]	<2.0 ppm [a]	7.4 – 9.5 [i]	Phytoplankton [hh]
Quagga mussel	Larvae	~12 [g, see p]	~25 [gg, see p]		20 [e] – 24 [d]	~20% or 2 ppm [f, see p]	~7.4 – 9.5 [i, see p]	Phytoplankton [hh]
	Veliger	~10 (growth) [ii, see p]	~25 [gg, see p]		20[e] – 24[d]		~7.4 – 9.5 [i, see p]	Phytoplankton [hh]
	Adult	5 – 9 (spawning) [l, m]	30 (mortality) [n]	15°C, between <5 & >95% RH [j]	~8.3 – 32 see jj, e	>4.0 mg L^{-1} (survival) [k]	~7.4 – 9.5 [i, see p]	Phytoplankton [hh]
New Zealand mudsnail		<18 [u]	32 [bb]	14°C , between 20 & 100% RH [q]	8 – 9 [o]	>6.7 mg L^{-1} (survival) [b]		Diatoms, detritus, & attached periphyton [r]
Asian Clam		0 – 2 [t]	24 – 34 [see t]	15 'C, between <5% & 75% RH [h]	4 – 5 [kk]	1.0 – 3.0 mg L^{-1} [c]	>6.5 [kk]	Phytoplankton [kk]
Signal crayfish		3 – 5.5 [z]	33 [x]	Gills must remain moist [ll]	5 [y]	<9.09 mg L^{-1} [dd]	5.8 [aa]	Vascular detritus [ee]
Conditions in Lake Tahoe		~4 [v]	25 (summer surface) [w]; 5.5 (winter surface) [w]	NA	8 – 10 [s, k] 23.4 (near clam beds) [mm]	10.9 mg L^{-1} (100 –150 feet) [w]	7.72 – 8.07 [cc]	NA

[a] Nichols 1992, [b]Alonso and Camargo 2003, [c] Belanger 1991, [d] Sprung 1987, [e] Cohen and Weinstein 2001, [f] Baker et al. 1993, [g] Sprung 1983, [h] Byrne et al. 1988, [i] 100th Meridian Initiative, [j] Ussery and McMahon 1995, [k] Cohen 2007, [l] Roe and MacIsaac 1997, [m] Claxton and Mackie 1998, [n] Spindle 1994, [o] Kolosovich and Chandra 2008, [p] Cohen 2005, [q] Richards et al. 2004, [r] Hanlon 1981, [s] cited in Hackey et al. 2008, [t] Janech and Hunter 1995, [u] NZMMPWGP 2007, [v] Goldman 1988, [w] TERC 2008, [x] Nyström 1999, [y] Wolf 2004, [z] Bubb et al. 2002, [aa] Wolf 2004, [bb] Quinn et al. 1994, [cc] Imboden et al. 1977, [dd] Usio et al. 2005, [ee] Guan and Wiles 1998, [ff] Stanczykowska and Lewandowski 1993, [gg] Claudi and Mackie 1994, [hh] USGS 2008, [ii] Karatayev et al. 1998, [jj] Hinks and Mackie 1997, [kk] Wittmann et al. 2008, [ll] GISD 2008, [mm] Chandra and Wittmann unpublished data

It is well established that dreissenid mussels were introduced to the U.S. via ship ballast water (O'Neill 1994). The survival of dreissenid mussels on trailered recreational watercraft; however, has not been fully investigated and much information is anecdotal at best. It is known that adult zebra mussel entangle in macrophytes on boat trailers and larvae can survive in boat engine cooling systems, live wells, and bait buckets – the more likely mechanisms of inter-lake transport (Johnson et al. 2001). To develop a better understanding of the survivability of dreissenid mussels during overland transport, laboratory experiments have been conducted at variable temperatures and relative humidities. Overall, dreissenid mussel mortality increases at higher air temperature and decreases at higher relative humidity (Payne 1992; Ricciardi et al. 1995). In controlled experiments conducted at 50% relatively humidity, adult zebra mussels are capable of surviving out of water for *at least* 16 days at 5°C (similar to winter conditions at Lake Tahoe) and *at least* three days at 20°C (similar to summer conditions at Lake Tahoe) (Ricciardi et al. 1995; Ussery and McMahon 1995; Table F-2 and Table F-3). Considering it takes far less than three days to travel to Lake Tahoe from zebra mussel infested waters (e.g., San Justo Reservoir) there is reason for substantial concern. Based on monthly averages of minimum temperature and maximum relative humidity, the 100th Meridian Initiative has developed a "Quarantine Estimator" (http://100thmeridian.org/emersion.asp). Using this estimator, watercraft quarantine time in the Tahoe area would require between three and 28 days (100th Meridian Initiative 2008). Three days assumes consecutive freezing temperatures. In general, it is recommended that infested boats be out of the water for 30 days.

Table F-2. Zebra Mussel Survival Durations for Selected Temperatures and Relative Humidity*

	Days to 100 Percent Mortality at Air Temperature, °C		
Relative Humidity (%)	5	15	25
95	26.6	11.7	5.2
50	16.9	7.5	3.3
5	10.8	4.8	2.1

*Based on the model: ln D = 5.917 – 0.082T + 0.010 RH; where T = temperature, °C and RH = relative humidity, % (adapted from Payne 1992 based on studies by Dr. Robert F. McMahon and Mr. Thomas A. Ussery, University of Texas at Arlington)

Table F-3. Mean Percent Survivorship of Zebra Mussel in Air at Three Different Exposures (1, 3, 5 Days) of Combinations of Three Levels of Relative Humidity (10, 50, 95%) and Ambient Temperature (10, 20, 30°C)*

Mussel length, 10.0 – 18.0 mm									
	10°C			20°C			30°C		
%RH	1d	3d	5d	1d	3d	5d	1d	3d	5d
10	93.3	26.7	0	66.7	3.3	0	0	0	0
50	93.3	90.0	3.3	72.5	3.3	0	0	0	0
95	96.7	90.0	73.3	96.7	70.0	13.3	33.3	0	0
Mussel length, 21.0 – 28.0 mm									
	10°C			20°C			30°C		
%RH	1d	3d	5d	1d	3d	5d	1d	3d	5d
10	93.3	36.7	25.0	96.7	13.3	0	60.0	0	0
50	100	100	100	96.7	73.3	16.7	77.5	0	0
95	100	100	100	100	100	47.5	100	3.3	0

*Taken from Ricciardi et al. 1995

Calcium has been considered a key factor in limiting the distribution of dreissenid mussels. Research suggests calcium concentrations between 8.3 mg Ca L^{-1} and 25 mg Ca L^{-1} is needed for shell development and maintenance and that 32 mg Ca L^{-1} results in maximum growth (Hinks and Mackie 1997; USGS 2008). Using existing reports and published values, Cohen and Weinstein (2001) summarized calcium thresholds for various life stages of zebra mussels (Table F-4).

Table F-4. Summary of Calcium Thresholds for Zebra Mussel Life Stages*

Endpoint	Calcium Threshold (mg/l)[3]	Source
Fertilization/Embryonic Development		
Release of sperm	15	Hincks & Mackie 1994
Normal success in egg fertilization	between 4 and 22	Baldwin et al. 1998
≥50% mean success in completing first cleavage	4	Lynn, pers. comm. 1998
Larval Development		
Development of some larvae, 0-3 days	between 0 and 12	Sprung 1987
Significant numbers of healthy larvae, 0-3 days	between 12 and 24	Sprung 1987
Some veliger production	between 8 and 20	Hincks & Mackie 1997
Normal success in development from fertilization to D-shell veliger	between 4 and 22	Baldwin et al. 1998
Normal success in development from D-shell veliger to juvenile	between 4 and 22	Baldwin et al. 1998
Veliger survival	between 11 and 16.5	Nierzwicki-Bauer, pers. comm. 2001
Juvenile Stage		
Normal juvenile (5 mm shell) survival for 35 days	between 3 and 4	Baldwin et al. 1998
Normal juvenile growth rate	between 7 and 24	Hincks & Mackie 1993
Juvenile growth (based directly on data)	between 8 and 20	Hincks & Mackie 1997
Juvenile growth (based on regression)	8.5	Hincks & Mackie 1997
Adult Stage		
Nonnegative calcium flux in unacclimatized adults	13-14	Vinogradov et al. 1987
Nonnegative calcium flux in unacclimatized adults	14	Vinogradov et al. 1993
Nonnegative calcium flux in acclimatized adults[1]	22	Vinogradov et al. 1993
Some adult (10-15 mm shell) survival for 35 days (based directly on data)	between 8 and 20	Hincks & Mackie 1997
Some adult (10-15 mm shell) survival for 35 days (based on regression)[2]	≈30 at pH≤7.4 0-25 at pH of 7.5-8.3	Hincks & Mackie 1997
Normal adult (15 mm length) survival for 35 days	between 3 and 4	Baldwin et al. 1998
Maintenance of tissue weight for 35 days	between 4 and 22	Baldwin et al. 1998

[1] Acclimatized for 28 days in diluted artesian water with 0.8-1.5 mg/l of calcium.

[2] Threshold calculated from multiple logistic regression model, for adult survival of ≤5%. By t he same model, calcium levels must be *below* 50 mg/l for adult survival at pH≥9.1.

[3] The indicated calcium level is the minimum concentration needed to satisfy the endpoint, as indicated by data or analyses in the cited sources.

*Adapted from Cohen and Weinstein 2001

Based on calcium requirements, Cohen and Weinstein (1998) assessed the potential for 160l California waterbodies to support zebra mussels. Suitability was based on the existing literature on calcium and pH tolerances. In that study, they determined Lake Tahoe has "low or no colonization potential". Similarly, Cohen (2007) estimated potential dreissenid mussel habitat in California assuming a lower calcium limit of 12 mg Ca L^{-1} and concluded that Lake Tahoe is "not vulnerable to colonization". Using water chemistry data from the U.S. EPA's Environmental Monitoring and Assessment Program (USEPA EMAP), Whittier et al. (2008) similarly defined environments with less than 12 mg Ca L^{-} as "low risk". Dreissenid mussels were, however, recently found in the Big Thompson Water Project in Colorado where calcium levels are known to seasonally fall below 12 mg L^{-1} in some regions (Crawfoot et al. 1996).

Current research by the UNR and TERC-UCD using water from Lake Tahoe and quagga mussels from Lake Mead suggest that at least adults are capable of surviving up to 50 days in Lake Tahoe water where open water calcium concentrations range from 8 to 12 mg Ca L^{-1} (Chandra and Wittmann unpublished data). Research by Chandra and Wittmann is underway to determine whether increased calcium concentrations associated with Asian clam beds could facilitate dreissenid mussel establishment as suggested by Stewart et al. (1998).

4.3 NEW ZEALAND MUDSNAIL (*POTAMOPYRGUS ANTIPODARUM*)

New Zealand mudsnails are tiny snails (less than 5 mm) that appear more like grains of sand and can reach densities near 500,000 and 800,000 snails m^{-2} (Hall et al. 2003 and Dorgelo 1987, respectively). New Zealand mudsnails are voracious primary consumers of diatoms, periphyton, and epiphyton (Hall et al. 2003, Riley et al. 2002) and often displace native macroinvertebrates through competition (Richards et al. 2001, Kerans et al. 2005). Secondary consumers such as trout are known to ingest New Zealand mudsnails; however, the mudsnails pass undigested and provide little to no nutritional value (Ryan 1982, McCarter 1986).

Native to fresh- and brackish water systems of New Zealand, the first observation of mudsnails in the U.S. was in the Snake River, Idaho; however, this species is now present in most all western U.S. states. The nearest population of New Zealand mudsnails to the Tahoe Region is in the Lower American River, below Lake Natoma (Figure F-2).

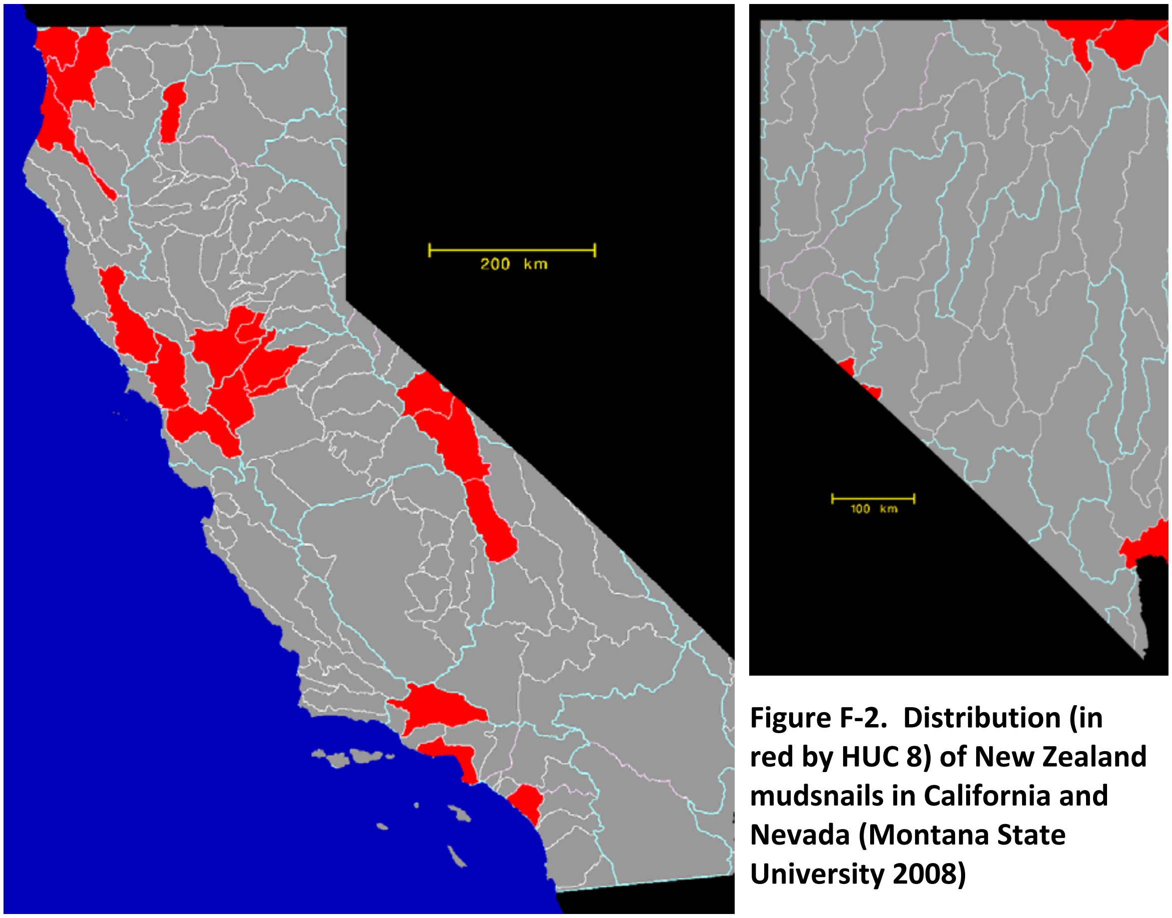

Figure F-2. Distribution (in red by HUC 8) of New Zealand mudsnails in California and Nevada (Montana State University 2008)

Life history

Populations of New Zealand mudsnails in North America are all believed to be parthenogenic females, meaning fertilization is not required for egg development and the populations are clonal (Dybdahl and Lively 1995). New Zealand mudsnails are viviparous (live-bearing) and approximately 20 to 120 embryos per female are produced each cycle, typically in the spring and summer (summarized by Montana State University 2008). The presence of an operculum (covering) allows them to survive out of the water for several weeks provided conditions are suitable (moist conditions and mild temperature).

Invasive life strategies

New Zealand mudsnails are highly invasive because their diminutive size allows for easy transport, they can survive out of the water for several weeks, and they are inconspicuous in color. They are commonly transported by anglers and boats through contaminated waders, boots, and fishing gear (NZMMPWG 2007). The result is that unaware anglers and boaters transport mudsnails within and between waterbodies. New Zealand mudsnails not only crawl at rates estimated at 1 m hr^{-1} (Montana State University 2008) but they are capable of crawling upstream (Haynes et al. 1985). Their ability to pass the digestive tract of fish also allows for upstream movement (Haynes et al. 1985). The combination of high fecundity rate (up to six generations per year, Vinson 2004) and broad environmental tolerances account for the rapid distributional success within and between watersheds.

Environmental requirements

New Zealand mudsnails tolerate a wide range of environmental conditions and habitats including, lakes, reservoirs, rivers, ditches, and estuaries and can tolerate up to 17 to 24% salinity (Bondesen and Kaiser 1949) (see Table 1). The preferred substrate of mudsnails ranges widely and includes silt, sand, gravel, cobble, and emergent vegetation (Richards et al. 2001). The species is tolerant of water temperatures that range from freezing to about 28°C (Crosier and Malloy 2008) (Table 1). Dybdahl and Kane (2005) evaluated life history responses of four populations of New Zealand mudsnails. They found that at 24°C reproduction ceased and that at 18°C reproduction occurred earlier when snails were smaller and offspring numbers were higher than those at 12°C. Levri et al. (2007) found New Zealand mudsnails in 18 m of water in Lake Erie. Recent research suggests that waterbodies characterized by specific conductance of 25 to 200 $\mu S\ cm^{-1}$ are unlikely to support New Zealand mudsnails (Herbst et al. 2008).

Their diminutive size allows easy transport on moist fishing gear, waders, rafts, and other recreational or field equipment. The presence of an operculum (a plate that covers the shell opening) on New Zealand mudsnails allows them to survive prolonged desiccation and, as previously mentioned, passing the digestive tract of secondary consumers (e.g., fish). They can survive up to 32°C, cold water temperatures, and salinities from 17 to 24% (Bondesen and Kaiser 1949). Preliminary research results by UNR suggest a 4 to 50% short-term (three week) survivability of New Zealand mudsnails in Lake Tahoe (http://www.cabnr.unr.edu/chandra).

4.4 Signal Crayfish (*Pacifastacus leniusculus*)

Crayfish were introduced multiple times to Lake Tahoe and established by 1936. By the late 1960's numbers of crayfish were estimated up to 55 million. They are thought however to support the lake's newest warm water fish invaders, largemouth bass.

Signal crayfish are large, hardy, cool temperate freshwater crayfish found in rivers and lakes. The signal crayfish is native to the Columbia River system in North America but intentional introductions have occurred across Europe and Japan for commercial harvesting as food (Hiruta 1999, Usio et al. 1999, Holdich 2002, Machino and Holdich 2006) and even to replace a declining indigenous population in Sweden in 1960. Outside their native range, the signal crayfish impacts native populations of crayfish, macroinvertebrates, benthic fish, and aquatic macrophytes largely due to its polytrophic feeding behavior (Guan and Wiles 1997, Nyström 1999, Westman and Savolainen 2001, Lewis 2002). They are an aggressive competitor and have been responsible for displacing indigenous crayfish species wherever they have been introduced. In addition, they act as a vector for the crayfish plague fungus, *Aphanomyces astaci*, to which all non-North American crayfish are susceptible, but to which it is relatively immune (Huber and Schubart 2005).

Sooty crayfish (*Pacifastacus nigrescens*), a native to the western U.S., has become extinct partly due to interspecific competition with signal crayfish, which was introduced into its range. Signal crayfish have also been implicated in causing a reduction in the range of the already narrowly endemic Shasta crayfish (*Pacifastacus fortis*) in the western U.S. (Taylor 2002). In California, the signal crayfish has been introduced to Lakes such as Castle, Donner, and Tahoe, and the Sacramento River (Goldman and Rundquist 1977, Elser et al. 1994, Lewis 2002). The signal crayfish was most likely introduced to Lake Tahoe in 1895 and again in 1909 to provide food for other introduced fish species (La Rivers 1962). Ironically, crayfish intentionally collected from Lake Tahoe for stocking have become a nuisance elsewhere (Westman and Savolainen 2001).

Life history

Signal crayfish display opportunistic polytrophic feeding habits, although more animal than plant material will be consumed if available (GISD 2008). They are very active and migrate up and down rivers, as well as move overland around obstacles. However, their rate of colonization is relatively slow and may only be about 1 km per year. In one stream in England it took 17 years for them to spread 12 km downstream (Stanton 2004). They were once considered to be a non-burrowing species, but have since been documented constructing burrows under rocks or in river and lake banks (Guan 1994; Sibley 2000). Their burrows can reach high densities, i.e., 14 per meter, and they can have a serious impact on bank morphology, causing undermining and collapse.

Invasive life strategies

Signal crayfish are large and relatively fast-growing with high fecundity. Consequently, they have proved a good aquacultural species and support capture fisheries in the western U.S. and Europe, particularly in Finland and Sweden (GISD 2008). Studies suggest that under low densities (0.16 adults m^{-2}) crayfish stimulate periphyton productivity by removing old senescent cells (Flint and Goldman 1975). Higher densities (1.07 adults m^{-2}) however result in decreased periphyton production. At either density, crayfish have been found to excrete nitrogen and phosphorus which are important stimulators of primary production. Today crayfish no longer contribute to the energetics of non-native lake trout except for the largest size classes (> 21 inches).

Environmental requirements

Signal crayfish occupy a wide range of habitats from small streams to large and natural lakes, including sub-alpine lakes, such as Lake Tahoe and Donner Lake (Lowery and Holdich 1988; Lewis 2002). This species also grows well in culture ponds and is tolerant of brackish water and high temperatures but does not occur in waters with a pH lower than 5.8 (Table F-1).

Predatory fishes (e.g., largemouth bass and bluegill) impact crayfish populations by direct consumption and by forcing crayfish to seek shelter. In absence of other prey species, crayfish comprise up to 60% of largemouth bass diets (Gelwick 2000). When predators are present, crayfish change their behavior by taking shelter in weed beds (Blake et al. 1994), move to deeper water (Gelwick 2000), and exhibit predator avoidance movement such as swimming backwards.

In crayfish, temperature regulates behaviors such as molting, growth, and reproduction. Extreme temperature fluctuation can result in death if molting fails to occur (Nakata et al. 2002). The optimal growth temperature for signal crayfish is around 23°C with an upper limit of 33°C (Nyström 2002). Crayfish can remain out of the water as long as their gills remain moist. For crustaceans, calcium obtained from the water and food must be sufficient for exoskeleton production after molting. Insufficient calcium levels after molting renders soft exoskeletons, leaving them more vulnerable to predation. The lower calcium limit suggested for crayfish is 5 mg Ca L^{-1} and uptake is impaired below pH 5.8 (Wolf et al. 2004).

4.5 BULLFROG (*RANA CATESBEIANA*)

The North American bullfrog is distributed worldwide due largely to aquaculture because it is an edible frog species and by the aquarium trade as an ornamental species (GISD 2008). This species is often blamed for population declines in various indigenous species (Bury and Whelan 1984) and is considered among the 100 worst invaders in the world (Adams and Pearl 2007). The primary concerns of bullfrog establishment are competition with, and predation upon, native herpetofauna by adults which prey upon native anurans and other aquatic herpetofauna such as snakes and turtles (King et al. 2002). Larvae can have a significant impact upon benthic algae (GISD 2008). Additionally, recent studies now imply that bullfrogs serve as a reservoir of *Batrachochytrium dendrobatidis* (Hanselmann et al. 2004), a fungus that is causing amphibian declines worldwide. Because post-metamorphic bullfrogs can disperse long distances (> 1200m) to establish new sites and can carry this deadly disease without succumbing to the disease, this increases the potential threat of bullfrogs as an aquatic invader to an even higher level.

Bullfrogs were first collected in Lake Tahoe in 1948 near Taylor Creek Meadows (USGS 2008) and remain the only *known* invasive amphibian in the Lake Tahoe Basin. Native amphibians that may have been impacted by bullfrogs include the Endangered Species Act (ESA) candidate species, the Sierra Nevada yellow-legged frog (*Rana sierrae*), historically found throughout the Lake Tahoe Basin, the threatened California red-legged frog (*Rana aurora draytonii*) which is native to areas adjacent and west to the Basin (Lawler et al. 1999; Doubledee et al. 2003); and the Pacific chorus frog (*Pseudacris sierra*) and long-toed salamander (*Ambystoma macrodactylum sigillatum*) which currently have stable populations within the Basin (NatureServe 2009).

Life History

External fertilization of unshelled eggs takes place as the eggs are deposited in water. The jelly-coated eggs form a floating raft which may measure as much as a meter across (GISD 2008). Bullfrogs lay a single mat of eggs that can be removed as they float on top of the surface of the water. After being layed, the eggs float for 1 to 2 days, after which they sink to the bottom where they become very cryptic.

Eggs typically hatch in 3-5 days. Bullfrogs breed from early spring through late summer, depending upon local climate. Gravid females commonly contain from 1,000 to 20,000 eggs, with larger females producing larger clutches. Maximum clutch size is over 40,000 eggs. They will produce multiple clutches per-season under favorable conditions (GISD 2008). These amphibians undergo a completely aquatic life stage before metamorphosing into semi-aquatic adults. This larval stage is variable in length, from 4 months to over 2 years, taking longer in colder climates (GISD 2008).

Invasive Life Strategies

Bullfrogs are most often imported into a country or area for commercial food production but have sometimes been introduced, inadvertently, along with fishes raised in hatcheries where bullfrog larvae are abundant (GISD 2008) or by the accidental release of tadpoles used as bait. In some cases, bullfrogs have been deliberately introduced to control agricultural pests. Once established in an area, bullfrogs are capable of considerable overland travel, and will eventually disperse throughout entire watersheds, given interspersed patches of suitable aquatic habitat (GISD 2008).

The population growth rate of bullfrogs is strongly influenced by survival rate of metamorphs and juveniles. One of the factors that may determine survival of metamorphs is the presence of migration corridors and nearness of suitable ponds during the fall migration (Govindarajulu et al. 2005). It has been suggested that bullfrog larvae may be able to recognize cues of novel predators, which could contribute to their success as an invasive species (Pearl et al. 2003). In Oregon, the invasion of bullfrogs appears to have been facilitated by the presence of the non-native sunfish (including bluegill); native dragonfly nymphs reduce survival of bullfrog tadpoles unless sunfish are present to reduce dragonfly density (Adams et al. 2003). Tadpoles can digest the nuisance, bloom forming blue-green algae *Anabaena* spp., which may explain the competitive advantage they have over native anurans at the larval stage (Pryor 2003). Bullfrog tadpoles will also prey on the tadpoles of other species (Kiesecker et al. 2001).

Environmental Requirements

Bullfrogs inhabit a variety of freshwater habitats, including lakes, reservoirs, rivers, creeks, streams, et cetera. Bullfrog tadpoles prefer vegetated areas and medium depths in the early stages of development, and deeper water in the later stages (Smith 1999).

Adult bullfrogs are voracious, opportunistic predators of aquatic, terrestrial, and flying invertebrates and vertebrates, including birds (Lopez-Flores et al. 2003) and other amphibians (Chivers et al. 2001). Although diet studies have documented tendencies towards prey selectivity, a complete list of prey items suggests a willingness to eat almost any animal it can overpower and swallow whole (GISD 2008). In Colusa National Wildlife Refuge, California, crayfish (*Procambarus clarkii*) make up the majority of the bullfrogs diet (Wylie et al. 2003).

5 Literature Cited

Adams, M., C. Pearl, and R. Bury. 2003. Indirect facilitation of an anuran invasion by non-native fishes. Ecology Letters. 6(4):343-351.

Adams, M.J. and C.A. Pearl. 2007. Problems and opportunities managing invasive bullfrogs: is there any hope? In: Biological Invaders in Inland Waters: Profiles, Distribution, and Threats. Springer Netherlands

Aguirre, W. and S.G. Poss. 1999. Non-indigenous species in the Gulf of Mexico Ecosystem: *Corbicula fluminea (Muller, 1774)*. Gulf State Marine Fisheries Commission (GSMFC).

Alonso, A., J. Camargo. 2003. Short-term toxicity to ammonia, nitrite, and nitrate to the aquatic snail *Potamopyrgus anitpodarum (Hydrobiidae, Mollusca)*. Bulletin of Environmental Contamination and Toxicology. 70:1006-1012.

Baker, P., S. Baker, and R. Mann. 1993. Criteria for Predicting Zebra Mussel Invasions in the Mid-Atlantic Region. School of Marine Science, College of William and Mary, Gloucester Point, VA.

Balcom, N.C. 1994. Aquatic Immigrants of the Northeast, No. 4: Asian Clam, *Corbicula fluminea*. Connecticut Sea Grant College Program.

Barnes, G.E. and B.J. Hicks. 2003. Brown bullhead catfish (*Ameiurus nebulosus*) in Lake Taupo. *In:* Munro, R. (Ed.). Managing Invasive Freshwater Fish in New Zealand. New Zealand Department of Conservation. Wellington, New Zealand.

Baylis, J.R., D.D. Wiegmann, and M.H. Hoff. 1993. Alternating life histories of smallmouth bass. Transactions of the American Fisheries Society. 122(3):500-510.

Belanger, S.E. 1991. The effect of dissolved oxygen, sediment, and sewage treatment plant discharges upon growth, survival and density of Asiatic clams. Hydrobiologia. 218:113-126.

Belanger, S.E., J.L. Farris, D.S. Cherry, and J. Cairns, Jr. 1985. Sediment preference of the freshwater Asiatic clam, *Corbicula fluminea*. The Nautilus. 99(2-3):66-73.

Berra, T. 2001. Freshwater Fish Distribution. San Diego, CA. Academic Press. 604 pp.

Blake, M. P. Nyström, and P. Hart. 1994. The effect of weed cover on juvenile signal crayfish (*Pacifastacus leniusculus* Dana) exposed to adult crayfish and non-predatory fish. Biol. Bull. 205: 26-35.

Bondesen, P. and E.W. Kaiser. 1949. *Hydobia* (*Potamopyrgus*) *jenkinsi* (Smith) in Denmark illustrated by its ecology. Oikos 1:252-281.

Bouldan, B.R., G.C. VanEeckhout, H.W. Quade, and J.E. Gannon. 1994. *Potamogeton crispus* – the other invader. Lake and Reservoir Management. 10:113-125.

Boylen, C.W., L.W. Eichler, and J.D. Madsen. 1999. Loss of native aquatic plant species in a community dominated by Eurasian watermilfoil. Hydrobiologia. 415:207-211.

Boylen, C.W., L.W. Echler, J.S. Bartkowski, and S.M. Shaver. 2006. Use of geographic information systems to monitor and predict non-native aquatic plant dispersal through north-eastern North America. Hydrobiologia. 570:243-248.

Brayshaw, C. T. 2000. Pondweeds, Bur-reeds and their Relatives of British Columbia. Royal British Columbia Museum, Victoria, British Columbia. 250 pp.

Bubb, D.H., M.C. Lucas, and T.J. Thom. 2002. Winter movements and activity of signal crayfish *Pacifastacus leniusculus* in an upland river, determined by radio telemetry. Hydrobiologia 483: 111-119.

Bury, R.B. and J.A. Whelan. 1984. Ecology and management of the bullfrog. U.S. Fish and Wildlife Service. Publication 155. Washington, DC, 23 pp.

Byrne, R., R. McMahon, and T. Dietz. 1988. Temperature and relative humidity effects on aerial exposure tolerance in the freshwater bivalve, *Corbicula fluminea*. Biological Bulletin. 175:253-260.

Carpenter, S.R. 1980. The decline of *Myriophyllum spicatum* in a eutrophic Wisconsin lake. Canadian Journal of Botany. 58:527-534.

Chadderton, W. L. 2003. Management of invasive freshwater fish: striking the right balance! *In:* Munro, R. (Ed.). Managing Invasive Freshwater Fish in New Zealand. New Zealand Department of Conservation. Wellington, New Zealand.

Chambers, P.A. and J. Kalff. 1985. Depth distribution and biomass of submersed aquatic macrophyte communities in relation to secchi depth. Canadian Journal of Fisheries and Aquatic Sciences. 4(4):701-709.

Chandra, S., K.L.C. Ngai, M. Kamerath, and B. Allen. 2009. Warm-water non-native fishes in Lake Tahoe. Report prepared for Elizabeth Harrison, Nevada State Lands.

Chivers, D., E. Wildy, J. Kiesecker, and A. Blaustein. 2001. Avoidance response of juvenile Pacific treefrogs to chemical cues of introduced predatory bullfrogs. Journal of Chemical Ecology. 27(8):1667-1676.

Claudi, R. and G.L. Mackie. 1994. Practical Manual for Zebra Mussel Monitoring and Control. Lewis Publishers. Boca Raton, FL.

Claxton, W.T., and G.L. Mackie. 1998. Seasonal and depth variations in gametogenesis and spawning of *Dreissena polymorpha* and *Dreissena bugensis* in eastern Lake Erie. Canadian Journal of Zoology. 76(11):2010-19.

Cohen, A. N. and A. Weinstein. 1998. The Potential Distribution and Abundance of Zebra Mussels in California. San Francisco Estuary Institute. Richmond, CA.

Cohen, A. N. and A. Weinstein. 2001. Zebra Mussel's Calcium Threshold and Implications for its Potential Distribution in North America. San Francisco Estuary Institute. Richmond, CA.

Cohen, A.N. 2005. A Review of Zebra Mussels' Environmental Requirements. California Department of Water Resources. San Francisco Estuary Institute. Oakland, CA.

Cohen, A.N. 2007. Potential Distribution of Zebra Mussels (*Dreissena polymorpha*) and Quagga Mussels (*Dreissena bugensis*) in California: Phase 1 Report. California Department of Fish and Game. San Francisco Estuary Institute. Oakland, CA.

Crosier, D. and D. Malloy. 2008. New Zealand mudsnail (Potamopyrgus antipodarum) species description. http://www.anstaskforce.gov/spoc/nzms.php

Crowfoot, R.M., R.C. Ugland, W.S. Maura, R.A. Jenkins, and G.B. O'Neill. 1996. Water Resources Data for Colorado, Water Year 1995. Volume 2. Colorado River Basin. U.S. Geological Survey, Water Resources Division, Lakewood, CO.

Dedual, M. 2002: Vertical distribution and movements of brown bullhead (*Ameiurus nebulosus Lesueur 1819*) in Motuoapa Bay, southern Lake Taupo, New Zealand. Hydrobiologia. 483:129–135.

Doll, B. 1997. Zebra Mussel Colonization: North Carolina's Risks. Sea Grant North Carolina, University of North Carolina. Raleigh, NC. (UNC SG-97-01).

Dorgelo, J. 1987. Density fluctuations in populations (1982-1986) and biological observations of *Potamopyrgus jenkinski* in two trophically differing lakes. Hydrobiological Bulletin. 21:95-110.

Doubledee, R.A., E.B. Muller, and R.M. Nisbet. 2003. Bullfrogs, disturbance regimes, and the persistence of California red-legged frogs. Journal of Wildlife Management 67(2): 424-438.

Dybdahl, M.F. and C.M. Lively. 1995. Diverse, endemic and polyphyletic clones in mixed populations of the freshwater snail *Potamopyrgus antipodarum*. Journal of Evolutionary Biology. 8:385-398.

Dybdahl, M.F., and S.L. Kane. 2005. Adaptation versus phenotypic plasticity in the success of a clonal invader. Ecology. 86(6):1592-1601.

Elser, J.J., C. Junge, and C.R. Goldman. 1994. Population structure and ecological effects of the crayfish *Pacifastacus leniusculus* in Castle Lake, California. Great Basin Naturalist. 54(2):162-169.

Eng, L.L. 1979. Population dynamics of the Asiatic clam, *Corbicula fluminea* (Muller), in the concrete-line Delta-Mendota Canal of Central California. Proceedings of the International *Corbicula* Symposium 1:40-68.

Flint, R.W. and C.R. Goldman. 1975. The effects of a benthic grazer on the primary productivity of the littoral zone of Lake Tahoe. Limnology and Oceanography 20(6): 935-944.

Fuller, P., L.G. Nico, and J.D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society Special Publication 27. Bethesda, Maryland.

Garton, D. W. and W.R. Haag. 1993. Seasonal reproductive cycles and settlement patterns of *Dreissena polymorpha* in western Lake Erie. *In*: Zebra Mussels: Biology, Impacts, and Control. T.F. Nalep and D.Schlosser (Eds.). CRC Press, Inc. pp. 111-128.

Gelwick, F.P. 2002. Grazer identity changes the spatial distribution of cascading trophic effects in stream pools. Oecologia 125(4): 573-583.

GISD (Global Invasive Species Database). 2008. The Global Invasive Species Database. Invasive Species Specialist Group (ISSG) of the IUCN Species Survival Commission. http://www.issg.org/database/welcome/.

Goldman, C. 1988. Primary production, nutrients, and transparency during the early onset of eutrophication in ultra-oligotrophic Lake Tahoe, California-Nevada. Limnology and Oceanography. 33(6 part 1):1321-1333.

Goldman, C.R. and J.C. Rundquist. 1997. A comparative ecological study of the California crayfish *Pacifastacus leniusculus* (Dana), from two subalpine lakes (Lake Tahoe and Lake Donner). Freshwater Crayfish 3: 51-80.

Govindarajulu, P. R. Altwegg, B. Anholt. 2005. Matrix model investigation of invasive species control: bullfrogs on Vancouver Island. Ecological Applications. 15(6):2161-2170.

Guan, R. 1994. Burrowing behavior of signal crayfish, Pacifastacus leniusculus (Dana), in the River Great Ouse, England. Freshwater Forum. 4:155-168.

Guan, R. and P. Wiles. 1997. Ecological impact of introduced crayfish on benthic fishes in a British lowland river. Conservation Biology. 11(3):641-647.

Guan, R. and P. Wiles. 1998. Feeding ecology of the signal crayfish Pacifastacus leniusculus in a British lowland river. Aquaculture. 169(3-4):177-193.

Hackley, S., B. Allen, G. Schladow, J. Reuter, S. Chandra, and M. Wittmann. 2008. Lake Tahoe Aquatic Invasive Species Incident Report: Notes on visual observations of clams in Lake Tahoe and on the beaches along the southeast shore – Zephyr Cove to Timber Cover Marina: April 25, 2008.

Hall, J.J. 1984. Production of immature *Corbicula fluminea (Bivalvia:Corbiculidae)*, in Lake Norman, North Carolina. The Nautilus. 98(4):153-159.

Hall, R.O., J.L. Tank, and M.F. Dybdahl. 2003. Exotic snails dominate carbon and nitrogen cycling in a highly productive stream. Frontiers in Ecology and the Environment. 1:407-411.

Hanlon, R. 1981. The influence of different species of leaf litter on the growth and food preference of the prosobranch Molluscs *Potamopyrgus jenkinsi (*E. A. Smith*)*. Archives of Hydrobiologie. 91:463-474.

Hanselmann, R., A. Rodriquez, M. Lampo, L. Fajardo-Ramos, A.A. Aguirre, A.M. Kilpatrick, J.P. Rodriquez, and P. Daszak. 2004. Presence of an emerging pathogen of amphibians in introduced bullfrogs *Rana catesbeiana* in Venezuela. Biological Conservation 120(1): 115-119.

Haynes, A., B.J.R. Taylor, and M.E. Varley. 1985. The influence of the mobility of *Potamopyrgus jenkinsi* (E.A Smith.) (*Prosobranchia: Hydrobiidae*) on its spread. Archives Hydrobiologia. 103:497-508.

Herbst, D.B., M.T. Bogan, and R.A. Lusardi. 2008. Low specific conductivity limits growth and survival of the New Zealand mudsnail from the Upper Owens River, California. Western North American Naturalist 68(3): 324-333.

Higgenbotham, B. 1988. Forage Species: Range, Description, and Life History. Southern Regional Aquaculture Center. Texas Agricultural Extension Service, College Station, Texas. L-2398. SRAC Publication No. 140.

Hinks, S.S. and G.L. Mackie. 1997. Effects of pH, calcium, alkalinity, hardness, and chlorophyll on the survival, growth, and reproductive success of zebra mussel (*Dreissena polymorpha*) in Ontario Lakes. Canadian Journal of Fisheries and Aquatic Sciences. 54: 2049-2057.

Hiruta, S-i. 1999. The present status of crayfish in Britain and the conservation of the native species in Britain and Japan. Journal of Environmental Education 2: 119-132.

Holdich, D.M., 2002. Biology of Freshwater Crayfish. Blackwell Science, Oxford. 702 pp.

Huber, M. and C. Schubart. 2005. Distribution and reproductive biology of Austropotamobius torrentium in Bavaria and documentation of a contact zone with the alien crayfish Pacifastacus leniusculus. Bulletin Francais de la Peche et de la Pisciculture. 376-77:759-776.

Imboden, D.M., R.F. Weiss, H. Craig, R.L. Michel, and C.R. Goldman. 1977. Lake Tahoe Geochemistry Study 1. Lake chemistry and tritium mixing study. Limnology and Oceanography 22(6): 1039-1051.

Janech, M. and R. Hunter. 1995. *Corbicula fluminea* in a Michigan river: implications for low temperature tolerance. Malacological Review. 28:119-124.

Johnson, L.E. and J.T. Carlton. 1996. Post-establishment spread in large-scale invasions: dispersal mechanisms of the zebra mussel *Dreissena polymorpha*. Ecology. 77(6):1686-1690.

Johnson, L.E., A. Ricciardi, and J.T. Carlton. 2001. Overland dispersal of aquatic invasive species: a risk assessment of transient recreational boating. Ecological Applications. 11(6):1789-1799.

Kamerath, M., S. Chandra, and B.C. Allen. 2008. Distribution and impacts of warm water fish in Lake Tahoe, USA. Biological Invasions. 3(1):35-41.

Karatayev, A.Y., Burlakova, L.E., and Padilla, D.K. 1998. Physical factors that limit the distribution and abundance of *Dreissena polymorpha (Pall.)*. Journal of Shellfish Research. 17(4):1219-35.

Kerans, B.L., M.F. Dybdahl, M.M. Gangloff, and J.E. Jannot. 2005. *Potamopyrgus antipodarum*: distribution, density, and effects on native macroinvertebrate assemblages in the Greater Yellowstone Ecosystem. Journal of North American Benthological Society. 24(1):123-138.

Kiesecker, J., A. Blaustein, C. Miller. 2001. Potential Mechanisms Underlying the Displacement of Native Red-Legged Frogs by Introduced Bullfrogs. Ecology. 82(7):1964-1970.

King, C.A., C.J. Langdon and C.L. Counts, III. 1986. Spawning and early development of *Corbicula fluminea (Bivalvia: Corbicularidae)* in laboratory culture. American Malacological Bulletin. 4(1):81-88.

King, K., J. Rorabaugh, and J. Humphrey. 2002. *Rana catesbeiana* (bullfrog) diet. Herpetological Review. 33(2):130-131.

Kolosovich, A. and S. Chandra. 2008. Invasion potential of the New Zealand mudsnail in Lake Tahoe and the Lower Truckee River (USA). Abstract. 2008 Ocean Sciences Meeting.

Kraft, C. 1994. *Zebra Mussel Update #1*. University of Wisconsin-Madison, Wisconsin Sea Grant Institute.

La Rivers, I. 1962. Fishes and Fisheries of Nevada. Nevada State Fish and Game Commission. Carson City, NV. 782 pp.

Lawler, S., D. Dritz, T. Strange, and M. Holyoak. 1999. Effects of introduced mosquitofish and bullfrogs on the threatened California red-legged frog. Conservation Biology. 13(3):613-622.

Levri, E.P., A.A. Kelly, and E. Love. 2007. The invasive New Zealand mudsnail (*Potamopyrgus antipodarum*) in Lake Erie. Journal of Great Lakes Research. 33(1):1-6.

Lewis, S. 2002. Pacifastacus. In: Holdich, D. (Ed.). Biology of Freshwater Crayfish. Blackwell Science, Oxford: 511-540 pp.

Lopez-Flores, M., J. Cruz-Burgos, and F. Vilella. 2003. Predation of a white-cheeked pintail (*Anas bahamensis*) duckling by a bullfrog (*Rana catesbeiana*). Caribbean Journal of Science. 39(2):240-242.

Lowery, R. and D. Holdich. 1988. Pacifastacus leniusculus in North America and Europe, with details of the distribution of introduced and native crayfish species in Europe. In: Holdich, D. M. and R.S. Lowery (Eds.). Freshwater Crayfish: Biology, Management and Exploitation. Croom Helm. London: 283-308 pp.

Machino, Y. and D. Holdich. 2006. Distribution of crayfish in Europe and adjacent countries: updates and comments. Freshwater Crayfish. 15:292-323.

Madsen, J. D. 1997. Seasonal biomass and carbohydrate allocation in a southern population of Eurasian watermilfoil. Journal of Aquatic Plant Management. 35:15-21.

Madsen, J. D. 1998. Predicting invasion success of Eurasian watermilfoil. Journal of Aquatic Plant Management. 36:28-32.

Madsen, J.D. and C.W. Boylen. 1989. Eurasian watermilfoil seed ecology from an oligotrophic and eutrophic lake. Journal of Aquatic Plant Management. 27:119-121.

Madsen, J.D., J.W. Sutherland, J.A. Bloomfield, L.W. Eichler, and C.W. Boylen. 1991. The decline of native vegetation under dense Eurasian watermilfoil canopies. Journal of Aquatic Plant Management. 29: 94-99.

Mattice, J. S. and L. L. Dye. 1976. Thermal tolerance of adult Asiatic clam. *In:* G.W. Esch and R.W. McFarlane, (Eds.). 2nd Proceedings of Thermal Ecology Symposium. II, ERDA Symposium Series.

May, B. and J.E. Marsden. 1992. Genetic identification and implications of another invasive species of Dreissenid mussel in the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences. 49:1501-1506.

McCarter, N.H. 1986. Food and energy in the diet of brown and rainbow trout from Lake Benmore, New Zealand. New Zealand Journal of Marine and Freshwater Research. 20:551-559.

McDowall, R.M. 1990. New Zealand Freshwater Fishes: A Natural History and Guide. Heinnemann Reed. Auckland. 553 pp.

McGinnis, S. M. 1984. Freshwater Fishes of California. University of California Press. Berkeley, California. 316 pp.

McMahon, R. 1996. The physiological ecology of the zebra mussel, *Dreissena polymorpha*, in North America and Europe. American Zoologist. 36:339-363.

McMahon, R.F. and J. L. Tsou. 1990. Impact of European zebra mussel infestation to the electric power industry. Proceedings of the American Power Conference. 52:988-997.

Mills, E.L., G. Rosenberg, A.P. Spidle, M. Ludyanskiy, Y. Pligin, and B. May. 1996. A review of the biology and ecology of the Quagga mussel (*Dreissena bugensis*), a second species of freshwater Dreissenid introduced to North America. American Zoologist. 36:271-286.

Montana State University. 2008. Website: New Zealand Mudsnails in the Western U.S.A. Accessed 19 May 2008. http://www.esg.montana.edu/aim/mollusca/nzms/status.html.

Moody, M. L. and D.H. Les. 2007. Geographic distribution and genotypic composition of invasive hybrid watermilfoil (*Myriophyllum spicatum* x *M. sibiricum*) populations in North America. Biological Invasions. 9(5):559-570.

Morton, B., and K.Y. Tong. 1985. The salinity tolerance of *Corbicula fluminea (*Bivalvia:Corbiculoidea*)* from Hong Kong. Malacological Review. 18:91-95.

Moyle, P. B. 1976. Inland fishes of California. Berkeley, University of California Press.

Moyle, P. B. and R.D. Nickols. 1973. Ecology of some native and introduced fishes of the Sierra Nevada foothills in central California. Copeia. 3:478-490.

Nakata, K., T. Hamano, K-I Hayashi, and T. Kawai. 2002. Lethal limits of high temperature for two crayfishes, the native species *Cambaroides japonicus* and the alien species *Pacificastacus leniusculus* in Japan. Fisheries Science 68(4): 763-767.

NatureServe. 2009. An Online Encyclopedia of Life. http://www.natureserve.org/explorer/index.htm. Accessed 4 May 2009.

NDEP (Nevada Division of Environmental Protection). 2002. Nevada's 2002 303(d) Impaired Waters List. Nevada Division of Environmental Protection Bureau of Water Quality Planning. Carson City, NV

Netherland, M.D., J.D. Skogerboe, C.S. Owens, and J.D. Madsen. 2000. Influence of water temperature on the efficacy of diquat and endothall versus curlyleaf pondweed. Journal of Aquatic Plant Management. 38:25-32.

Nichols, S. 1992. Life history and ecological requirements of the zebra mussel: North American experience through 1992. National Biological Survey. Ann Arbor, MI. http://www.seagrant.noaa.gov/funding/zmlifehistory.html.

Nichols, S.A. and B.H. Shaw. 1986. Ecological life histories of the three aquatic nuisance plants, *Myriophyllum spicatum*, *Potamogeton crispus*, and *Elodea canadensis*. Hydrobiologia. 131(3):3-21.

Nyström, P. 1999. Ecological Impact of Introduced and Native Crayfish on Freshwater Communities: European Perspectives. In: Gherardi, F. and D. Holdich, (Eds.). Crustacean Issues 11: Crayfish in Europe as Alien Species (How to make the best of a bad situation?) A. Balkema, Rotterdam, Netherlands.

NZMMPWG [New Zealand Mudsnail Management Plan Working Group]. 2007. National Management and Control Plan for the New Zealand Mudsnail (*Potamopyrgus antipodarum*).

O'Neill, C. 1994. The introduction and spread of the zebra mussel in North America. Proceedings of the Fourth International Zebra Mussel Conference, Madison, WI.

Page, L.M. and B.M. Burr. 1991. A Field Guide to Freshwater Fishes of North America North of Mexico. Houghton Mifflin Company, Boston. 432 pp.

Payne, B.S. 1992. Aerial exposure and mortality of zebra mussels. Technical Note ZMR-2-10, Zebra Mussel Research Program, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Pearl, C., M. Adams, G. Schuytema, and A. Nebeker. 2003. Behavioral responses of anuran larvae to chemical cues of native and introduced predators in the Pacific Northwestern United States. Journal of Herpetology. 37(3):572-576.

PFBC (Pennsylvania Fish and Boat Commission). 2000. Pennsylvania Fishes. Pennsylvania Fish and Boat Commission Bureau of Boating and Education Educational Media Section.

Pimentel, D., S. McNair, S. Janecka, J. Wightman, C. Simmonds, C. O'Connell, E. Wong, L. Russel, J. Zern, T. Aquino, and T. Tsomondo. 2001. Economic and environmental threats of alien plant, animal and microbe invasions. Agriculture, Ecosystems and Environment 84: 1-20.

Pryor, G. 2003. Growth rates and digestive abilities of bullfrog tadpoles (*Rana catesbeiana*) fed algal diets. Journal of Herpetology. 37(3):560-566.

Quinn, J., G. Steele, C. Hickey, and M. Vickers. 1994. Upper thermal tolerances of twelve New Zealand stream invertebrate species. New Zealand Journal of Marine and Freshwater Research. 28:391-397.

Ricciardi, A., R. Serrouya, and F.G. Whoriskey. 1995. Aerial exposure tolerance of zebra and quagga mussels (Bivalvia: Dreissenidae): implications for overland dispersal. Canadian Journal of Fisheries and Aquatic Science. 52:470-477.

Richards, D. C., L.D.Cazier, and G.T. Lester. 2001. Spatial distribution of three snail species, including the invader *Potamopyrgus antipodarum*, in a freshwater spring. Western North American Naturalist. 61(3):375-380.

Richards, D.C., P. O'Connell, and D.C. Shinn. 2004. Simple control method to limit the spread of the New Zealand mudsnail *Potamopyrgus antipodarum*. North American Journal of Fisheries Management. 24:114-117.

Richardson, W.B., S.J. Zigler, and M.R. Dewey. 1998. Bioenergentic relations in submerged aquatic vegetation: an experimental test of prey by juvenile bluegills. Ecology of Freshwater Fishes. 7(1):1-12.

Riley, L.A., M.F. Dybdahl, and R.O. Hall. 2002. Invasive species impact: resource competition between stream snails within the Greater Yellowstone Ecosystem. *In*: Final Report: The Invasiveness of an Exotic Snail in the Greater Yellowstone Ecosystem and Energy Flow under Ambient Conditions.

Roe, S.L., and H.J. Maclsaac. 1997. Deepwater population structure and reproductive state of quagga mussels (*Dreissena bugensis*) in Lake Erie. Canadian Journal of Fisheries and Aquatic Sciences. 54(10):2428-33.

Ryan, P. A. 1982. Energy contents of some New Zealand freshwater animals. New Zealand Journal of Marine and Freshwater Research. 16:283-287.

Sastroutomo, S.S. 1981. Turion formation, dormancy, and germination of curlyleaf pondweed, *Potamogeton crispus L*. Aquatic Botany. 10:161-173.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Bulletin of the Fisheries Research Board of Canada. 184:1-966.

Sheldon, R. B. and Charles W. Boylen. 1977. Maximum depth inhabited by aquatic vascular plants. The American Midland Naturalist. 97(1):248-254.

Sibley, P. 2000. Signal Crayfish Management. In: The River Wreake Catchment. Rogers, D. and J. Brickland, (Eds.). Crayfish Conference Leeds. Environment Agency, Leeds: 95-108.

Sigler, W.F. and J.W. Sigler. 1987. Fishes of the Great Basin: A Natural History. Reno, Nevada. University of Nevada Press.

Smith, C. S. and J.W. Barko. 1990. Ecology of Eurasian watermilfoil. Journal of Aquatic Plant Management. 28:55-64.

Smith, G. 1999. Microhabitat preferences of bullfrog tadpoles (*Rana catesbeiana*) of different ages. Transactions of the Nebraska Academy of Sciences. 25(0):73-76.

Sorba, E. and D. Williamson. 1997. Zebra Mussel Colonization Potential in Manitoba, Canada. Water Quality Management Section. Manitoba Environment. Report No. 97-07.

Spindle, A. 1994. A Comparison of Exotic Bivalves, the Quagga Mussel (*Dreissena bugensis Andrusov*) and the Zebra Mussel (*D. polymorpha Pallas*), Using Genetic Variation and Tolerance to Temperature and Salinity. M.S. Thesis. Cornell University. Ithaca, New York.

Sprung, M. 1987. Ecological requirements of developing *Dreissena polymorpha* eggs. Archiv für Hydrobiologie – Supplement. 79:69-86.

Sprung, M. 1993. The other life: an account of present knowledge of the larval phase of *Dreissena polymorpha*. *In:* Zebra Mussels: Biology, Impacts, and Control. Nalepa, T.F. and D.W. Schloesser, (Eds.). Lewis Publishers. Boca Raton, FL.

Stanczykowska, A., and K. Lewandowski. 1993. Thirty years of studies of *Dreissena polymorph*a in Mazurian Lakes of northeastern Poland. *In:* Zebra Mussels: Biology, Impacts, and Control. Nalepa, T.F. and D.W. Schloesser, (Eds.). Lewis Publishers. Boca Raton, FL.

Stanton, J. 2004. Burrowing Behavior and Movements of the Signal Crayfish. Unpublished PhD. Thesis, University of Leicester, UK. 169 pp.

Stewart, T.W., J.G. Miner, and R.L. Lowe. 1998. Quantifying mechanisms for zebra mussel effects on benthic macroinvertebrates: organic matter production and shell-generated habitat. Journal of North American Bentholocial Society 17: 81-94.

SWRCB (State Water Quality Control Board). 2003. 2002 Federal Clean Water Act Section 303(d) list of Water Quality Limited Sections.

Taylor, C. 2002. Taxonomy and Conservation of Native Crayfish Stocks. In: Holdich, D., (Ed.). Biology of Freshwater Crayfish. Blackwell Science. Oxford.

Turner, J.L. 1966. Distribution and food habits of centrarchid fishes in the Sacramento-San Joaquin Delta. p. 144-153. *In*: J.L. Turner and D.W. Kelly (comp.) Ecological Studies of the Sacramento-San Joaquin Delta. Part II Fishes of the Delta. Fish. Bull. 136.

USDA-NRCS (U.S. Department of Agriculture - Natural Resource Conservation Service). 2008. The PLANTS Database (http://plants.usda.gov, 17 June 2008). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

USGS (U.S. Geological Survey). 2008. Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/. Accessed 23 April 2008

Usio, N., H. Nakajima, R. Kamiyama, I. Wakana, S. Hiruta, and N. Takamura. 2005. Predicting the distribution of invasive crayfish (*Pacifastacus leniusculus*) in a Kusiro Moor marsh (Japan) using classification and regression trees. Ecological Resources. 21:271–277.

Usio, N., K. Nakata, T. Kawai, and S. Kitano. 1999. Distribution and control status of the invasive signal crayfish (*Pacifastacus leniusculus*) in Japan. Japanese Journal of Limnology. Japanese Society of Limnology.

Ussery, T.A. and R.F. McMahon. 1995. Comparative Study of the Desiccation Resistance of Zebra Mussels (*Dreissena polymorpha*) and Quagga Mussels (*Dreissena bugensis*). Technical Report EL-95-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Vinson, M. 2004. The Occurrence and Distribution of New Zealand Mud Snail (*Potamopyrgus antipodarum*) in Utah. Final Report to Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City, Utah 84114. http://www.esg.montana.edu/aim/mollusca/nzms/utah-sep2004.pdf

Waters, T.F., J.P. Kaehler, T.J. Polomis, and T.J. Kwak. 1993. Production dynamics of smallmouth bass in a small Minnesota stream. Transactions of the American Fisheries Society. 122(4):588-598.

Werner, E. E. and D.J. Hall. 1988. Ontogenetic habitat shifts in bluegill: the foraging rate-predation risk trade-off. Ecology. 69(5):1352-1366.

Werner, R.G., B.V. Jonckheere, M.D. Clapsadl and J.M. Farrell. 1996. A bioenergetic exploration of piscivory and planktivory during the early life history of two species of freshwater fishes. Marine and Freshwater Research. 47:113-121.

Westman, K. and R. Savolainen. 2001. Long term study of competition between two co-occurring crayfish species, the native *Astacus astacus* L. and the introduced *Pacifastacus leniusculus* Dana, in a Finnish lake. Bull. Fr. Pêche Piscic 361: 613-627.

Whittier, T. R., P.L. Ringold, A.T. Herlihy, and S.M. Pierson. 2008. A calcium-based invasion risk assessment for zebra and quagga mussels (*Dreissena spp.*). Frontiers in Ecology and the Environment; 6, doi: 10.1890/070073.

Wittmann, M., S. Chandra, J. Reuter, and G. Schladow. 2008. Asian clam and Lake Tahoe: Preliminary Findings and Future Needs. Technical Report. University of California Davis, TERC and University of Nevada Reno.

Wolf, M., V. Rainer, and P. Moore. 2004. Spatial arrangement of odor sources modifies the temporal aspects of crayfish search strategies. Journal of Chemical Ecology. 30:501-517.

Wylie, G., M. Casazza, and M. Carpenter. 2003. Diet of bullfrogs in relation to predation on giant garter snakes at Colusa National Wildlife Refuge. California Department of Fish and Game. 89(3):139-145.

Appendix G: Summary of Comments

The Lake Tahoe Region AIS Management Plan was reviewed by numerous agencies, most of which are represented on the LTAISWG and/or the LTAISCC (see Appendix D). The following is a summary of comments (C:), sorted by organization in alphabetical order, and the applicable response (R:). In most cases, comments were addressed by Tetra Tech staff, but additional support was provided by the LTAISCC review subcommittee. Not included are editorial or duplicated comments and many are specific to previous versions of the Plan such that references to specific sections, appendices, et cetera may no longer match.

Aquatic Nuisance Species Task Force (ANSTF)

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C: The Draft Lake Tahoe Region ANS Management Plan appears to have completely addressed all the required elements for an interstate management plan. Once any comments are incorporated into the plan, I recommend its approval by the ANSTF.

R: So noted

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General Comments

C: The draft should have been thoroughly edited for grammar, a large number of minor errors (i.e., missing words, incomplete acronyms, format). Public NGO stakeholder input was limited to the Tahoe Keys Property Owners Association, California Tahoe Conservancy, League to Save Lake Tahoe, and California Trout. A public comment period appears to be coinciding with Task Force review. I would have much preferred reviewing a plan of this length after revisions derived from public comment.

R1: Other reviewers provided specific constructive comments for improving minor errors and additional edits are currently underway.

R2: *ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management Plans* allows for simultaneous 45-day ANSTF review and 30-day public comment period.

C: Obviously, a large and unique lake is the focus of the plan. This plan does not 1) adequately synthesize and logically present the host of complex biotic and abiotic factors at work and 2) recognize that this lake is fundamentally changed by these factors such that a clear set of goals and objectives moving forward has not been articulated. However, Appendix A [now Appendix E] does attempt a logical analysis and it is puzzling that this subcomponent to the plan was not effectively utilized, expanded, and built upon to create a sound, workable document. For example, the plan would be immeasurably improved if a complete and factual contextual biotic and abiotic analysis was included. Given the charge ascribed to the Tahoe Regional Planning Agency and the Lahontan Regional Water Quality Control Board, it is very surprising that such an analysis was not provided. Appendix A [now Appendix E] provides some context regarding historical development trends, population growth, and socio-economics. However, it does not provide information relative to surface water effects and wastewater treatment and disposal relative to impacts upon the lake benthos (biotic and abiotic) and water quality (lakewide trends and status as well as specific locations such as the Tahoe Keys).

R1: RE: 1 & 2…So noted, please see sections "Management Plan Goals" and "Management Plan Objectives, Strategies and Actions" in the Plan.

R2: RE: Appendix A [now Appendix E]…So noted; however, the intent of the economic assessment is to document potential economic risks which we believe was achieved.

R3: RE: "…the plan would be immeasurably improved if a complete and factual contextual biotic and abiotic analysis was included." This level of detail is not recommended in the *ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management Plans*. Also, resources are currently not available for this undertaking.

R4: RE: A [now Appendix E] and how "it does not provide information relative to surface water effects and wastewater treatment …" All wastewater generated in the Region is exported out of the Region and not discharged to Lake Tahoe. Surface water runoff is addressed in detail in the draft TMDL (now referenced in the Plan).

C: Mentioned several times in the plan is that an important aesthetic value to the lake, water clarity "may be indirectly affected by AIS." The potential link proposed is tenuous, nutrient pumping by rooted aquatic plants, and appears to avoid the underlying issue which is anthropogenic nutrient contributions. Until nutrient contribution is elucidated it is very clear the plan addresses a continuing outcome of land use and population management. If this is the case, then the plan authors should formulate a plan that describes a perennial AIS management/maintenance effort that will be balanced against the desire by certain population segments to maintain a recreational fishery consisting, primarily, of a variety of nonnative fish that benefit from aquatic plants.

R1: Added text: "This loss in clarity has resulted in listing Lake Tahoe as water quality impaired according to Section 303(d) of the federal Clean Water Act (CWA). In response, a total daily maximum load (TMDL) is being developed by the states of California and Nevada to address nitrogen, phosphorus and fine sediment loading that impact the optical properties of the water (Roberts and Reuter 2007)."

R2: The reference to nutrient pumping by aquatic plants illustrates a mechanism by which plants can change water quality and is not intended to fully describe all means of increased nutrients. Reference to the TMDL in R1 addresses other nutrient sources.

R3: The intent of the Plan is not to address all non-native fish, but rather the warm water fishes that do not support recreational activities. Additionally, in an effort to remain consistent with the CAISMP, warm water fishes are not targeted as an invasive species.

R4: Studies are currently underway (as mentioned in the Plan) to look at the interaction between non-native aquatic plants and warm water fishes. Results will be incorporated into future Plan revisions (Action A2c) using an adaptive management approach.

C: If the plan is not significantly revised as suggested, then it is obvious there is a schizophrenic nature to this plan and this strongly hints that there will be significant conflict and lack of progress in its implementation. Conflict resides in the clearly articulated desire to control, manage and prevent nonnative species as well as reluctant recognition of the value (ecological and economic) associated with nonnative species. This conflict might be resolved if the proposed management goals, page 72, included the goal of objectively assessing the biological, ecological, and economic values, positive and negative, of existing nonnative species. By including a fundamental assessment of the identity, location and quantity of nonnative species that are desired by the various stakeholders, then the plan could be effectively structured and described.

R1: RE: first sentence, so noted.

R2: CDFG currently does not stock fish in Lake Tahoe and NDOW does not stock warm water fish.

R3: See above, warm water fishes are not considered a desirable fishery in Lake Tahoe (see Table 5 in the Plan).

C: Initially it seemed that the Lake Tahoe AIS Working Group or the Lake Tahoe AIS Coordination Committee would be the lead organization; however, on pages 9, 73 and 74, the Tahoe Regional Planning Agency (TRPA) is identified the lead organization. Strange as it may sound, an organizational chart would be helpful because of the relationship of the Lake Tahoe AIS Working Group, Lake Tahoe AIS Coordination Committee, and the TRPA is not explained. Fundamentally, are they related and does the TRPA have a role in directing the other two groups in their activities? Greater confidence in the implementation of this plan would be created through a TRPA statement or cover letter from the TRPA that they will be the responsible party and that it has management authority over the other two groups.

R1: The LTAISWG and the LTAISCC have no legal authority to act as lead since they both represent multiple regional, NGO, state, and federal agencies. Language added/rearranged to make the distinction between the LTAISWG, LTAISCC, and TRPA in the section “Plan Oversight” and clearly identify TRPA has a clear legal mandate between the states of California and Nevada and is best served as the lead for the Plan (TRPA Compact).

R2: A cover letter from the TRPA will accompany the submission of the Plan to the ANSTF in November.

Specific Comments

C: Executive Summary, second sentence: The sentence should be rewritten to include text that communicates what is meant by "harmful" and "far-reaching" and clarify or eliminate the phrase "invasive or aquatic invasive species."

R: Propose changing text from: "Substantial changes to the Lake Tahoe Region's economy, pristine water quality, aesthetic value, and recreational pursuits however, are occurring in part to harmful non-native plants, fish, clams, and other invaders. When the harmful impacts from non-native species becomes so far-reaching, they are considered "invasive", or *aquatic invasive species* (AIS) when they occur in or very near water."

to

"Substantial changes to the Lake Tahoe Region's economy, pristine water quality, aesthetic value, and recreational pursuits are occurring, partly due to the harmful impacts of aquatic, non-native plants, fish, clams, and other invaders. These non-native aquatic organisms are considered 'invasive' when they threaten the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, agricultural, aquacultural or recreational activities dependant upon such waters (NANPCA 1990), or…"

C: Page 1, first paragraph, third sentence: This sentence is confusing and in error. Accidental introductions are not "unregulated intentional introductions." All intentional introductions are regulated. California and Nevada laws prohibit introduction of nonnative aquatic species to state waters (see pages C-9 and C-14). As defined in the glossary, accidental introductions are the unintended result of an anthropogenic activity.

R: Propose changing text from: "Conversely, *accidental* introductions, or especially unregulated intentional introductions (e.g., "bait bucket biologists"), are generally viewed as undesirable and detrimental to the local landscape."

to

"Conversely, *accidental* introductions, or especially unauthorized intentional introductions, are generally viewed as undesirable and detrimental to the local landscape. " [DM asks to omit use of "bait bucket biologists"]

C: Page 4: Please include a lakewide benthic characterization. Describe locations subject to anthropogenic sediment (organic and inorganic) inputs.

R: Lakewide benthic invertebrate survey is currently underway by UNR as funded by the USACE.

C: Page 4: Please include a lakewide water quality characterization. Describe locations subject to anthropogenic nutrient input.

R: See above, added reference in the Plan to TMDL.

C: Page 4: It is patently disingenuous to describe lake water quality degradation and not include an analysis describing land and water use, anthropogenic nutrient contributions, and human population changes.

R: See above, added reference in the Plan to TMDL.

C: Page 6, Table 1: I believe the information relative to NANPCA/NISA is in error in that the Act and its amendments do not include regulations or programs relative to exportation, importation and possession. In addition, it is my belief NANPCA/NISA does include education/outreach, financial assistance, and technical assistance provisions.

R: Changed and added 'x': control, coordination, research, prevention per the request of S. Mangin

Page 11, Species Assemblages

C: This title of this section is misleading and/or the text is unfinished. The focus of this section is on fish but the title infers a summarization of species assemblages: flora and fauna. Please consider providing a flora and fauna summarization here and follow with subsections that thoroughly discuss the major taxonomic groups: fish, plants, molluscs, amphibians, crustaceans, reptiles, plankton, and (potentially) mammals. This discussion should include the biological and control information already provided but also include analysis of the species perception and value and prevention, management, control, or public education efforts. Clearly certain nonnative species are welcomed in certain portions of the Lake and not in others.

R1: Included ranking system (Tables 4 and 5) and moved much of this text to Appendix G [now Appendix F], per *ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management Plans*

R2: Species life histories and control methods moved to Appendix G [now Appendix F]

R3: The intent of this Plan is to address invasive species and not legal introductions of non-native species (as noted Table 5).

C: The last paragraph [pg. 11] alludes to the desirability of continuing to stock or allow the presence of certain nonnative fish species. The authors must provide considerable and additional analysis to justify this broad statement for text found in the plan that precedes this section indicates that these species are the focus of the plan and threaten nearby waterbodies. There appear to be differing goals/objectives between the two states relative to gamefish stocking. If that is the case, then this issue should be thoroughly explored including whether the states have jointly discussed their stocking plans and reached an agreement to their mutual satisfaction.

R: This point has been discussed by CDFG and NDOW. Both agree that game fish, as defined by law, will not be considered "invasive". Hopefully this point is clearer by providing a "Problem Definition and Ranking" section (as suggested by reviewer DM), where species will be ranked, similar to the CAISMP:

Table 3: Species Management Types

SPECIES MANAGEMENT TYPE	REPRESENTATIVE SPECIES	MANAGEMENT RESPONSE
Type 1 Not yet detected in California or eradicated	*Caulerpa* Northern Pacific seastar South African sabellid polychaete snakehead zebra mussel	Monitoring Early detection
Type 2 Limited in extent	Hydrilla channeled apple snail *Salvinia* smooth cordgrass quagga mussel	Early detection Rapid response Eradication
Type 3 Established but manageable	African clawed frog *Egeria* Chinese mitten crab Eurasian watermilfoil European green crab purple loosestrife salt cedar water hyacinth	Localized eradication Impact mitigation Control of spread to other water bodies Research on control technologies
Type 4 Widespread but currently no large-scale control options	Asian overbite clam inland silverside New Zealand mudsnail bullfrog water lettuce pale yellow iris	Monitoring Prevent spread to new water bodies Research
Type 5 Unknown invasion potential	Asian swamp eel green sunfish salt meadowcordgrass	Research and evaluation

The Species Management Type (SMT) characterizes the distribution and degree of establishment of an AIS in California and could be assigned to any AIS species. This characteristic is useful to consider when setting management priorities or planning for a management response to a potential or actual AIS infestation. Representative species are merely examples, as this table is not meant to provide a comprehensive list of species sorted by SMT. Though valid at the time of publication, the status of the species mentioned is likely to change over time. For more examples see Chapter 8.

C: Page 17: Please provide a full-page map of current nonnative aquatic plant distribution and acreage and an analysis as to why nonnative aquatic plants are found in specific locations (i.e., benthic characteristics, surface water inflows, nutrient sources, etc.). There is an inherent contradiction in describing the lake as being oligotrophic and projecting lakeshore wide spread of these plants. For example, a long-distance water circulation system, page 26, is being used to control a nonnative aquatic plant through the circulation of oligotrophic water.

R1: A full page map is provided (now in Appendix F). Exact acreage of plant distribution is not known and needs to be determined (Action D2b).

R2: Propose adding language about why non-native plants are located where they are, but this would be speculative as no detailed research has been conducted on the relationships between plant distribution and characteristics of Lake Tahoe.

R3: RE: "there is an inherent contradiction in describing the lake as being oligotrophic and projecting lakeshore wide spread of these plants". Eurasian watermilfoil is known to occur in a wide variety of waterbodies, from eutrophic to oligotrophic, and its distribution is not inherently limited by nutrients (as implied by trophic status). Sediment nutrients, dissolved gasses, and light availability are known to play a significant role in its distribution. Propose adding language reflecting the seemingly contradictory growth of weeds in an oligotrophic system *and* point out that the water quality in the Tahoe Keys does *not* reflect lake-wide conditions.

See:

Madsen, J.D., L.W. Eichler, and C.W. Boylen. 1988. Vegetative spread of Eurasian watermilfoil in Lake George, New York. Journal of Aquatic Plant Management 26: 47-50.

Sand-Jensen, K. and M. Søndergaard. 2006. Distribution and quantitative development of aquatic plant macrophytes in relation to sediment characteristics in oligotrophic Lake Kalgaard, Denmark. Freshwater Biology 9(1): 1-11.

R4: The water circulation systems (4 units) were isolated to the east basin of the Tahoe Keys, only used for three years, and are no longer in place.

R5: Added more information about how the Tahoe Keys and small embayments and marinas have very different water quality compared to Lake Tahoe as whole (see Section: Geographic Scope).

C: Page 63: The Lee et al 2007 paper describing zebra mussel management costs was a theoretical exercise and not an analysis of costs associated with an actual infestation. The citation for this paper and the Rockwell 2003 paper are missing from the list of cited literature.
See http://edis.ifas.ufl.edu/pdffiles/FE/FE69300.pdf for a fact sheet by Lee et al that was spun off from their theoretical economic modeling exercise. Zebra mussels are not present in Lake Okeechobee.

R: Deleted Lee et al. 2007 reference; Rockwell 2003 reference added to Lit Cited

C: Page 68: The TRPA Code 79.3 B (2) should be cited in the preceding 4.1 Recreational Activities section (actually of greater relevance in 4.1 than this section).

R: Moved to Recreational Activities

C: Page 81: The National Incident Command System is referenced but not explicitly adopted as an EDRR framework nor are there plan actions (i.e., D3) that indicate a NIMS approach will be developed, adopted, tested, and training offered to the agencies that commit resources. The NIMS should be adopted as this operational framework obviates a wasteful, redundant effort to develop species specific EDRR plans.

R: NIMS approach will be used to develop the *Lake Tahoe Region AIS EDRR Plan* (D3a) and the *Lake Tahoe Region Mussel EDRR Plan* (D3b)

C: Page A-6: The careful use and qualifications provided in this section relative to economic impact should be employed as well in earlier portions of the plan that attempt economic analysis or summary of economic impact analysis.

R1: [At the time of review, Appendix A = Potential Economic Impacts]. The LTAISCC feels the economic assessment should remain as a standalone document in the appendix with a more succinct version in the body of the plan.

R2: Removed Potential Economic Impacts section from body of Plan and referenced reader to Appendix for full assessment.

C: I suggested that the Lake Tahoe ANS management plan include additional lake water quality discussion. Attached are two articles that illustrate N, P, trophic state and sediment complexities. I don't think we should expect or require an in-depth analysis but the plan to manage ANS in Lake Tahoe should include enough water quality and biotic information to adequately support the activities they would like to implement and the outcomes they will be working to achieve. (Please see Conley attachments to the e-mail)

R: See above, the TMDL, the 208 Plan, LRWQCB Basin Plan, and the TRPA Regional Plan will be cited as they are overarching water quality plan/guiding documents that provide direction to policy makers on a variety of water quality objectives, for example to support beneficial uses and nondegradation standards by setting numeric targets (e.g., soluble phosphorus, total phosphorus, total nitrogen, total soluble inorganic nitrogen, algal growth, plankton count, biological indicators, and clarity).

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I have no comments to make on the Draft Lake Tahoe Plan. I found it to be well written and covered all necessary aspects of an AIS management plan.

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As a member of the Aquatic Nuisance Species Task Force, the Forest Service has completed its review of the Lake Tahoe Region Aquatic Invasive Species Management Plan and recommends that this plan receives full acceptance by the chairmen and membership of the Task Force. The review of this plan was important to us and our reviewers felt that the plan was very proactive, thorough and well-written.

The Forest Service plays a key role in management of the Lake Tahoe region, we are proud that the USFS-Lake Tahoe Basin Management Unit (LTBMU) is serving a vital role in addressing aquatic invasive species. In particular, the LTBMU Forest Plan, developed under the National Forest Land Management Act, guides multiple use management and sets direction for accomplishing aquatic ecosystems goals and objectives, including aquatic invasive species management considerations. Forest Service personnel in the LTBMU are engaged in a number of aquatic invasive species management functions including: prevention, treatment and research. Additionally, the Forest Service manages a variety of recreation sites that provide the public both direct (i.e. boat launches) and indirect (i.e. campgrounds) access to Lake Tahoe and other waterbodies. LTBMU aquatic program staff are also fully engaged in aquatic invasive specie prevention strategies at recreation facilities. In addition, LTBMU aquatic biologists have taken a leadership role in restoring aquatic habitat for native species by removing and/or controlling aquatic invasive species.

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The Lake Tahoe Region Aquatic Invasive Species Management Plan (Tahoe Plan) sets a clear direction and a strong vision for the prevention of new introductions of aquatic invasive species into the Lake Tahoe Basin Region and the control and management of those AIS already established in the Sound. The Tahoe Plan is a wonderful addition to the activities already being accomplished under the CAISMP and additional work being completed in the State of Nevada.

While I find the plan as a whole to be well-done, I was especially pleased to see the strong collaboration of partners in the Lake Tahoe region; the diverse array of objectives, strategies, and actions outlined in the plan; and the well-detailed information on economics and impacts. I was also very encouraged to see Action F4e, which pertains to determining the extent to which existing AIS facilitate the establishment of new AIS.

The Plan also seems to meet most of the basic requirements of the Aquatic Nuisance Species Task Force's Guidelines. Despite these positive comments, however; I do have a some comments that I feel will improve the Tahoe Plan.

General Comments

C: **Format** – The document does not follow exactly the format laid out in the "ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management Plans." Although this is not a mandatory requirement, it makes it easier to review and revise if the document is laid out in the format provided by the Guidance.

R: Rearranged some sections to better fit the Guidance. For example, the Guidance suggests including economic impacts from AIS as an appendix, so this section was removed from main body (there was already some duplication).

C: **Format** – The document has an excellent table of contents, but the various sections of the document are not contained in chapters or sections with specific designation (Chapter 1, Section 1, whatever). When I combine this with the blank spaces that often occur in the document, I find the layout of the plan somewhat misleading. Blank areas, like the one on the bottom of page 2, or page 5 usually signify the end of a section and are somewhat confusing. Suggest adding Chapter or Section designation and removing blank pages whenever possible.

R: Added chapter and section numbers; removed as much blank space as possible to maintain readability.

C: **Problem Definition and Ranking** – The document does not contain a "Problem Definition and Ranking" section as laid out in the Guidance document. This is the section of an AIS management plan that provides an overall perspective of ANS problems and concerns, summarizes the histories of invasions, includes the number of species and taxa in various classes, describes pathways and evaluates economic and ecological costs and benefits of proposed actions. Although most of this information is in the plan in one place or another, it is not located together in one section.

Please refer to Section III (Plan Contents), C (Problem Definition and Ranking) for more information on this section.

One part of the Problem Definition and Ranking section definitely missing is the ranking of the AIS into two or more rankings/categories. Although this is not spelled out as clearly as it should be, ANS problems (usually taken to mean the various species by most plan developers) should be grouped into 3-5 categories. This allows for a clearer understanding about the ANS issues without prematurely emphasizing one problem over another.

As a potential solution, one might take the information in the last paragraph on page 18, combine it with the written introduction on page D-2, and create three categories of AIS in the Lake Tahoe Region. That information could then be integrated into Table 2, which should be rearranged and split into three tables based on the new categories. The categories might look like this:

1) AIS already existing in the Region;

3) AIS for which there is no operational means of controlling the species and prevention is essential; and

2) AIS whose introduction would cause irreversible damage to the ecological, economic, or human health within the Region.

Please note that this is just meant as an example based on information taken from the Lake Tahoe plan and I do not mean to imply that you must adopt this categorization. As an alternative to this explanation, you might consider just two categories: Those already in the Region and those who have a high potential for being introduced into the Region. Ultimately, I'd just like to see some sort of categorization as it facilitates easier decision making with large workloads and limited resources.

R: Added six species management types

C: **Climate Change** – Although the term "climate change" is mentioned numerous times in the Tahoe Plan, and is specifically mentioned on page 16 (Adaptive Management section) as something that should be considered as new information emerges. However, there was no specific action item regarding climate change in the Tahoe Plan. I suggest you consider putting a climate change action into the plan as it is something that may soon be a requirement for both new and revised plans.

R1: Not requested, but added action A2d. Considerations for Plan Revision. This action provides some guidance on when technical revisions are required (minor or major) and when a major overhaul is required.

R2: Added action F4f. Global Climate Change and AIS Establishment

Specific Comments

C: **Acknowledgements, Page iv** – The Acknowledgements on the Lake Tahoe do not include Sue Ellis from California Department of Fish and Game, the lead coordinator for the CAISMP. In addition, the plan mentions the CAISMP several times, but never gives any details on how the Lake Tahoe AIS Plan will interact with or complement the CAISMP. We recommend working closely with those implementing the CAISMP as the ANS Task Force's role is to seeks close coordination on AIS efforts and prevent duplication of efforts as often as possible.

R: Added Susan Ellis, CDFG, to the Acknowledgements

C: **Executive Summary, Page E-1** – The first paragraph describes AIS as occurring "in or near water." However, in this reviewer's opinion, species that occur "near water" are usually not considered aquatic species. In addition, the terms "aquatic invasive species" (AIS) and the term "aquatic" or "aquatic species": are not defined in the glossary. We suggest the two following definitions for consideration:

According to the Nonindigenous Aquatic Nuisance Prevention And Control Act Of 1990, the term aquatic nuisance species (ANS, now commonly referred to as AIS) is defined as: "a nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters."

According to ANS Task Force Document, "Aquatic Nuisance Species Program" developed in 1994, the term "aquatic species" is defined as: "all animals and plants as well as pathogens or parasites of aquatic animals and plants totally dependent on aquatic ecosystems for at least a portion of their life cycle."

R1: Removed "near" water

R2: Added "aquatic" and "aquatic invasive species" to the glossary

C: **Page E-**2 – Some acronyms are not spelled out the first time they are used. See LTAISWG on page E-2, and LTAISCC on page E-3.

R: Corrected

C: **Introduction, Page 1, First Paragraph** – The term "bait bucket biologist" is not an official invasive species term and is considered slang. Suggest removing it from the plan.

R: Removed

C: **Introduction, Page 1, Third Paragraph –** The first sentence refers to AIS as occurring "near water." See comments above on this topic.

R: So noted; removed

C: **Page 13, Last Paragraph –** The 5th sentence is confusing to me: "Unfortunately, the effectiveness of the stations to reduce AIS from entering Lake Tahoe are limited because both stations inspect west-bound traffic, meaning boaters arriving to Lake Tahoe from any direction essentially by-pass both BPSs." If west-bound traffic is inspected, should not the sentence read: Unfortunately, the effectiveness of the stations to reduce AIS from entering Lake Tahoe are limited because both stations inspect west-bound traffic, meaning boaters arriving to Lake Tahoe from any **other** direction essentially by-pass both BPSs.

R: Changed text to: "Unfortunately, the effectiveness of the stations to reduce AIS from entering Lake Tahoe are limited because both stations only inspect west-bound traffic and the Truckee station is northwest of the Region and the Meyers station is southwest of the Region. The result is boaters arriving to Lake Tahoe from any direction can easily by-pass both BPSs."

C: **Page 14, 2nd to Last Paragraph –** Despite the information preceding this paragraph, the paragraph seems misleading. It states that "If efforts are widely coordinated and all approved control tools are available, eradication of unwanted AIS is most likely to occur…" This seems misleading due to the factors mentioned in the list preceding that statement. Suggest rewording it to something like: "Well coordinated efforts and the availability of approved control tools, increase the likelihood of a successful eradication …"

R: Suggestion taken

C: **Page 15, Education –**The USFWS/ANSTF National Public Awareness campaign, Stop Aquatic Hitchhikers is mentioned in the Actions under Strategy C3, which states that it will "continue" to be utilized. However, there is no information on page 15 or anywhere else in the document of how the campaign has been utilized to date.

R: Changed text to: "Education is key to any effective prevention program. Based on the USFWS's Stop Aquatic Hitchhikers campaign, the message "Clean, Drain and Dry" is now common to visitors at Lake Tahoe. The TRCD delivers the campaign logo and slogan through flyers, regulatory boat launch signs, coozie's, training materials, highway billboards, television advertisements, and brochures. Most importantly, the message is reinforced by watercraft inspectors at boat launches."

C: **Page 17, Species Assemblages –** The introduction, species overview, Table 2 (but see comments above), overviews of species types (aquatic plants, warm water fishes, etc.) and the information on control and eradication techniques are all good information that should be kept in the main body of the plan. However, the specific species life histories would be better suited to an appendix as is outlined in the "ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management Plans." This comment should be combined with my earlier comment on the categorization of AIS species in the Lake Tahoe Region.

R: Added six species management types

C: Page 69, Pathways of Introduction – The implication that the seeds of AIS plants can "blown in" is not the best example as most aquatic plant seeds do not get transported by wind but rather by water (*Phragmites* is one example that does get transported by wind, but that is not even its best method of reproduction). Suggest rewording this to reflect that the seeds of most aquatic invasive plants are transported via water.

R: Suggestion taken

C: Page 74, Management Plan Goals, 2nd Sentence of Last Paragraph – Consider adding "and prevention" after the word outreach.

R: Suggestion taken

C: Page 75, Table 12 – There seems to be a typo in the third column of row D. A few words seems to be missing from item "b."

R: Corrected

C: Page 75, List of Objectives, Strategies, and Actions – With the exception of the capitalization of the objectives, the objectives, strategies, and actions all have the same formatting (tabs, bold, etc.) and it is difficult for the reader to distinguish between them. I suggest adding some additional formatting so that they are more easily distinguishable.

R: Additional formatting added

C: Page 77, Action A2c – ANS Management Plans are not currently "required" to be revised every 5 years, but it is highly encouraged.

R: Added reference to action A2d. Considerations for Plan Revision, that is, the Plan will be revised if needed, based on ANSTF criteria for minor/major technical revisions or major overhaul.

C: Page 78, Objective B – There is no mention of the QZAP (Quagga/Zebra Mussel Action Plan) currently under development by the Western Regional Panel of the ANS Task Force in the objective for Coordination and Collaboration, or anywhere else in the document that I could see. I highly suggest adding in some sort of collaboration/coordination with the QZAP and its implementers into the Lake Tahoe plan.

R: Changed text to: "Complete the Lake Tahoe Region Mussel EDRR Plan modeled after the Draft California Rapid Response Plan (CDFG 2008), the Columbia Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other Dreissenid Species (Columbia River Basin Team 2008), and the draft Aquatic Nuisance Species Task Force Quagga/Zebra Mussel Action Plan (under development by the Western Regional Panel), but tailored to the unique jurisdictional authority of agencies in the Lake Tahoe Region."

C: Page 79, Action B1b – This action does not seem to actually be an action but rather a statement about the value of meetings. Is the action the quarterly meetings? If so, then the action needs to be edited to make this clear. I noticed some other actions like this (B1c, C1b, and possibly others) and suggest that all the actions be reviewed to make sure the actions are clearly stated.

R1: Action B1b. LTAISCC and LTAISWG. Text changed to: "Continue monthly meetings of the LTAISCC and LTAISWG to identify and prioritize research needs, determine matching funds and share results between numerous agencies and organizations in the Tahoe Region.

R2: Action B1c. Annual LTAISWG Reports. Changed text to: "Continue synthesis and distribution of the annual LTAISWG summary of accomplishments and goals."

R3: Action C1b. Fee-based System to Support VIP. Changed text to: "Implement the TRPA Governing Board approved fee (effective June 1, 2009) to support the VIP adopted March of 2009. The fee will be assessed for each inspection of a motorized vessel. Vessels with an intact inspection seal that confirms that they last launched in Lake Tahoe are exempt from inspection and the fee. Reassess the fee on at least a yearly basis to determine if changes are needed, such as changes to the fee if other funds are found to offset costs."

C: **Page 79, Action B1d –** This is the first of many actions in the plan that consist of a single sentence; more detail for some of these actions may be helpful. Now I am not asking you to add information to these actions just to lengthen the document but because I feel that some of these actions would benefit from a little more detail. For example, for Action B1d, how will these partnerships be fostered and what is the benefit of these partnerships? As another example, for Action C1d, how will the locations for spot checks be chosen and who will conduct them? I suggest looking at each of the single-sentence actions and determine whether additional information would improve the understanding of the action.
For reference, the ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management Plans states: "Describe the specific work or task that will be performed to implement a strategy. Short statements detailing the work required and organizations involved and their respective roles should be prepared for each action. The expected result should be described.

R: Additional information added to select action items

C: **Page 82, Strategy C3, Education** – The USFWS/ANSTF Habitattitude National Public Awareness campaign, which targets aquarium owners and water gardeners, is not mentioned at all in the plan. I suggest adding an action to start using the Habitattituds or perhaps an effort to determine whether Habitattitude is appropriate for the Lake Tahoe region.

R: Added Action C3c. Habitatitude National Public Awareness Campaign.

Assess the appropriateness of using the USFWS/ANSTF Habitatitude National Public Awareness Campaign in the Region.

C: **Page 84, Action D2d** – This action, which pertains to a bullfrog monitoring plan, contains language regarding determining "associations with other invasive species that provide habitat structure or physical features along the shoreline that would serve as suitable habitat for colonization." I feel that this is an important aspect of monitoring that is often forgotten and would suggest that, if appropriate, this same activity be planned for each of the other monitoring actions.

R: Similar language added to the following actions: D2a, D2b, and D2c.

C: **Page 86, Objective E** – The second sentence of the second paragraph states: "The following strategies list methods that may or may not be available for use in the Tahoe Region to control AIS, however, their inclusion is meant to provide a broad view of available tools." The section of the plan on objectives, strategies and actions is where the plan outlines the work it plans to complete in the fight against AIS. It not the appropriate place for methods that may not be available for use in the area covered by the plan. That kind of information should be moved to sections of the document on control and eradication of various species assemblages (combined, of course, with my earlier comments about Problem Definitions and Ranking and moving the life history information to an appendix). If all the actions pertaining to "not yet available" control methods are worded so as to continue evaluation of the method in question, then I suggest rewording the initial statement in the objective to make it clear that the plan does not contain unnecessary actions.

R: Deleted quoted sentence. Changed text in Action E1f. Aquatic Herbicides to: "Continue to efforts to provide for all available control technologies, including the use of aquatic herbicides to control Eurasian watermilfoil and curlyleaf pondweed (Strategy G3) by working closely with the LRWQCB."

C: **Page 88, Action E3c; Page 92, Strategy G3** – The beginning of the sentence, which reads "Provide for all available control methods …" is unclear. The sentence should be reworded to make it more clear. This same comment can also be applied to the first sentence in Strategy G3 (page 92) which is almost the same statement and is still unclear.

R1: Actually Action E3e. Piscicides. Changed text to: ""Continue to efforts to provide for all available control technologies, including the use of piscicides to control warm water fishes (Strategy G3) by working closely with the LRWQCB."

R2: Strategy G3: Provide for All Appropriate Treatment and Control Measures. Changed text to: "At present, the use of aquatic pesticides to control or eradicate AIS in the Lake Tahoe Region is essentially unavailable to resource managers (see LRWQCB in Appendix A). Discussions between the LTAISCC and the LRWQCB should continue in an effort to provide for all available and appropriate technologies to meet the management goals of this Plan."

C: **Page 89, Strategy E4** – This strategy, whose actions pertain to the bullfrog, does not have an action regarding an eradication plan, but other strategies do. Is this an oversight or is it on purpose?

R: Language added

C: **Page 89-90, Strategies F2, F3, and F4 –** These strategies have no explanatory text. The ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management Plans states that for Objectives: "There should be one or more strategy statements describing the general approach that will be taken to attain each objective, and it or they should be included with the respective objective."

R: Corrected

C: **Page 91, Objective G** – The last sentence in the description of this objective references substantial gaps in AIS laws and regulations, however, this subject, which is a plan component mentioned in the ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management, is never actually covered anywhere in the plan or in Appendix A: Regulations and Programs. I suggest adding some information regarding gaps in laws and regulations in Appendix A.

R: Added Section: Gaps and Challenges

C: **Page 94, Implementation Table** –

In the first column, it is unclear what the green shading in some cells indicates.

The column labeled 'FY10-15 Anticipated Need" is unclear and requires further explanation. Does this single column and the funding levels within indicate the amount of funding needed for each of the 5 years? Or do the funding levels indicate the entire amount of funding needed over the 5 year time span? Most implementation tables for ANS plans split this column into it 5 separate years to eliminate any confusion. If the LTAISCC feels it is too difficult to separate things out into a full 5-ear time span, the ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management indicates (page 13), that "an alternative method is to develop a 5-year implementation strategy and a short-term action plan covering a period of not less than two years."

R1: Changed introductory text to: "Descriptions of the objectives, strategies, and actions above provide background and justification of each action item. Action items in green indicate current efforts at the time of writing. The implementation table identifies additional important elements of each action item, including: the lead and cooperating entities, priority levels, current funding levels and, where known, anticipated funding needs over the period 2010 to 2015."

R2: Added current/short-term actions

C: **Page 101, Priorities for Action** – This section could use a little bit more information on why the priorities indicated in the plan were chosen over other problems and concerns. The ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management states: "Priorities for action are established based upon the severity of a problem, the programmatic authority and scientific capability to resolve it, and the cost of the proposed solution. The plan should discuss the rationale for focusing on certain species, pathways, economic and ecological impacts, or other problems/concerns and not others. It should be explicit about which problems and concerns are to be addressed in this iteration of the plan and why they were included at this time while others were not."

R: Added rationale

C: **Page 102, Program Implementation and Review** – This section of the plan seems to be focused mostly on an "annual review to determine whether a formal revision of the plan is required." While this is certainly one important aspect of annual plan review, there are other important aspects of annual review including: assessing the effectiveness of management actions (have new introductions decreased? Did eradication or control methods work? Were education efforts successful) as well as discussion of unforeseen actions that impact progress. Please refer to the ANS Task Force Guidance for State and Interstate Aquatic Nuisance Species Management for more information on what is expected in this section of the plan.

R: Added focus items for future revisions

C: **Page A-2, Appendix 2, Lacey Act [now Appendix A]** – The section on the Lacey Act requires seems misleading and confusing. I suggest deleting the entire Lacey Act entry and replacing it with the following text:

Injurious Wildlife Provisions of the Lacey Act (18 U.S.C. 42; 50 CFR 16)
http://www.fws.gov/contaminants/ANS/ANSInjurious.cfm
http://www.fws.gov/laws/lawsdigest/lacey.html

The Service has broad authority to detain and inspect any international shipment, mail parcel, vehicle, or passenger baggage and all accompanying documents, whether or not *wildlife has been formally declared. The injurious wildlife provision of the Lacey Act is one tool that the U.S. Fish and Wildlife Service uses to prevent illegal introductions of and to manage invasive species. Under the Lacey Act, importation and interstate transport of animal species determined to be injurious may be regulated by the Secretary of the Interior. The Service implements the injurious wildlife provisions (18 U.S.C. 42) through regulations contained in 50 CFR Part 16. Species are added to the list of injurious wildlife to prevent their introduction or establishment through human movement in the United States to protect the health and welfare of humans, the interests of agriculture, horticulture or forestry, and the welfare and survival of wildlife resources from potential and actual negative impacts.*

Species listed as injurious may not be imported or transported between States, the District of Columbia, the Commonwealth of Puerto Rico, or any territory or possession of the U.S. by any means without a permit issued by the Service. Permits may be granted for the importation or transportation of live specimens of injurious wildlife and their offspring or eggs for bona fide scientific, medical, educational, or zoological purposes. This section of the Lacey Act also regulates that health certificates must accompany all imports of fresh or frozen fish produced commercially and salmon and trout harvested recreationally outside North American waters. Live salmon eggs also require health certificates.

The penalty for an injurious wildlife Lacey Act violation is up to six months in prison and a $5,000 fine for an individual or a $10,000 fine for an organization. Another section of the Lacey Act (16 U.S.C. 3371-3378) pertains to prohibited acts for wildlife and plants; this is different from the injurious wildlife provisions of the Lacey Act, though an enforcement relationship between the two does exist. Please see http://www.fws.gov/le/LawsTreaties/USStatute.htm for more information.

The current federal list of injurious wildlife species (50 CFR 16.11-16.15) may be found at http://www.gpoaccess.gov/cfr/index.html and do a "Quick Search" for "50CFR16".

R: Suggestion taken

California Department of Parks and Recreation (CADPR)

C: It would be helpful to have an introductory paragraph here stating what all the species are and how they were identified as primary concern. Due to the length of the section, it appears at first that just the dreissenids are of primary concern.

R: Text added: "For the purpose this Plan, species considered aquatic *invasive* species to the Lake Tahoe Region are indicated in **bold** in Table 2. In subsequent sections (i.e., Aquatic Plants, Warm Water Fishes, and Other Species), 13 species are further discussed. The rationale for providing more in-depth descriptions of these 13 species is that 1) they are existing infestations in the Region with a high potential for spreading within Lake Tahoe or other in-Region waterbodies, 2) introduction would cause irreversible damage to the ecological, economic, or human health within the Region, and/or 3) there is no operational means of controlling the species and prevention is essential."

C: from text "While native plant species such as *Elodea canadensis* and *Potamogeton foliosus* are found in Lake Tahoe, non-native Eurasian watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed (*Potamogeton crispus*) dominate the submersed aquatic plant community (Anderson 2007)." Please expand and indicate distribution of native aquatic plant species, i.e. prior to EWM and curlyleaf pond weed what was the distribution of native aquatic plants like? Now that the system has been invaded by invasive non-natives, the areas once occupied by natives have been displaced, or are the non-native invasive plants colonizing new areas, or both. My understanding is the latter.

R: Added text: "Surprisingly, prior to 1995, only one published reference to "Myriophyllum sp." (near Ward Creek and Tahoe City) has been documented (Flint and Goldman 1975) and all other evidence for aquatic plant distribution and species is anecdotal (Lars Anderson, USDA-ARS, May 14, 2009)."

C: First paragraph of section states who makes up the LTAISCC, should a sentence be added before the LTAISWG mission statement as to who makes up the group?

R: Participation in the LTAISWG is detailed in Appendix A

C: In reference to:"However, both quagga and zebra mussel larvae were found in the Big Thompson water project in Colorado where calcium concentrations are known to fall below 12 mg L^{-1} (Crowfoot et al. 1996)". Add something here about the increase in calcium near asian clam beds?

R: Text added

C: In reference to *Environmental Requirements* sections. Should this section include a discussion of how the requirements of the species [bluegill] relate to the existing conditions in Lake Tahoe and other waters in the Basin?

R: Added results from Chandra et al. (2009) on bluegill and largemouth bass diets in Lake Tahoe.

C: [Control/Eradication Methods for Other Species]. Are there any known impacts of the mentioned bio-control agents on native species? This should be addressed, even if to say there are no known impacts.

R: This method is still be evaluated and will not be recommended in the Plan

C: [Table 2. Non-native Species Presently In or Threatening Introduction to the Lake Tahoe Region]. Am I reading this right that there has been a shift from AIS in the Tahoe Basin to AIS in Lake Tahoe itself? Is there a reason for this change? Everything else has been directed to the basin as a whole. If this is for the entire basin, then the column in Tahoe has some changes to be made, such as the presence of bullfrogs. If you want to be Lake Tahoe specific, then what about adding a column for other water bodies in the Basin?

R: Shift focus to non-native species of the Lake Tahoe Region (as defined by TRPA)

C: Is there anything in the TRPA code that would prevent any of these materials [invertebrate anti-fouling materials] from being used in Lake Tahoe? It would be good if a statement were made either that they are all approved for use in the Lake or clarifying what is allowed if not all are approved.

R: Added text: "In the Tahoe Region, the use of antifouling coatings are restricted according to the Water Quality Management Plan for the Lake Tahoe Basin (208 Plan) and the Basin Plan, both summarized in Appendix A."

C: "Bottom barriers have been installed at Lake Tahoe - in a boat slip at Lakeside Marina and most recently (July 2008) at Ski Run and Emerald Bay." Any more information? How about when they were installed, the extent of the barriers, and results to date?

R: Added section: "Current aquatic plant control methods at Lake Tahoe". However, the purpose of an AIS Plan is not to address day-to-day control activities

C: If it is [milfoil weevil] used, would the dead vegetative material need to be removed, or would it be left to decompose in the Lake?

R: Not advised as this may also remove insects.

C: "Several methods for chemical control of Dreissena spp. have been used, but represent the least environmentally sensitive approach." What about Corbicula chemical controls? Probably should be considered here too.

R: Added chlorine and bromine

C: "Programs to educate the public about the impacts of AIS, methods to prevent introduction and further spread in the Basin, and control efforts are actively underway by several organizations …are summarized in Appendix A." Appendix A doesn't reflect the true effort of the prevention side that has been done in the Basin by TRCD et al. I think either here or in Appendix A the efforts should be better documented

R: Efforts added to Executive Summary

C: Under the species assemblage (Section 2) some invasive species are discussed in detail and some are not. Is there a determination being made that some of the invasives have a higher priority than others? How is this determination being made? For instance, Mysid shrimp impacts to the native crustaceans are mentioned, but no detailed discussion of potential control and biology are included. Is there concern related to the gill maggot?

R: Added text: "The rationale for providing more in-depth descriptions of these 13 species is that 1) they are existing infestations in the Region with a high potential for spreading within Lake Tahoe or other in-Region waterbodies, 2) introduction would cause irreversible damage to the ecological, economic, or human health within the Region, and/or 3) there is no operational means of controlling the species and prevention is essential."

C: Under control and Eradication methods, there is no discussion of potential control of signal crayfish or Mysid shrimp. Are these species too established to effectively manage the populations? Both seem to have had very severe impacts on the biotic systems in the lake.

R: see above

C: Has there been discussion whether to include the American beaver as an aquatic invasive species? Beaver activities may result in modification of habitat that might affect suitability of habitat for other invasive species including alteration of water temperature, water quality, chemical composition, and other impacts.

R: This species was not considered for this Plan.

C: More discussion of factors which could increase calcium concentration in Tahoe would be valuable. It seems like calcium is an important factor in shell development in many of the invasives.

R: See “Research Considerations: Environmental”

C: Are check stations along major highway points of entry into the basin an option for checking boats and positioning inspectors? This would likely be costly but might be more effective in regard to informing those with kayaks and canoes.

R: Language added to: AIS Management Approach, Prevention subsection

C: Smallmouth bass environmental requirements….introduction into the Truckee River downstream and migration up is a concern.

R: Added that smallmouth bass are found in the Truckee River near the confluence with the Little Truckee.

C: Site the source for signal crayfish replacing a declining indigenous population in Sweden. One citation I found was:
Westman, K. and R. Savolainen. 2001. Long term study of competition between two co-occurring crayfish species, the native *Astacus astacus* L. and the introduced *Pacifastacus leniusculus* Dana, in a Finnish Lake.

R: Noted

C: The California red-legged frog may not have been native to the Tahoe Basin. It occurs at lower elevations. Bullfrogs may be negatively impacting the other native amphibians in the basin (pacific tree frog, long-toed salamander).

R: Corrected

C: Are there any known impacts of the mentioned bio-control agents [to control dreissenid mussels] on native species? This should be addressed, even if to say there are no known impacts.

R: No known impacts but limited number of organisms evaluated

California Department of Fish and Game (CDFG)

California Natural Resources Agency ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF FISH AND GAME

http://www.dfg.ca.gov
North Central Region
1701 Nimbus Road, Suite A
Rancho Cordova, CA 95670
916-358-2900

April 8, 2009

Mr. Steve Chilton
Lake Tahoe Aquatic Invasive Species Coordination Committee Chair
U. S. Fish and Wildlife Service
128 Market Street
Stateline, NV 89449

Subject: California Department of Fish and Game Comments on the Lake Tahoe Aquatic Invasive Species Management Plan for the Lake Tahoe Basin, California and Nevada

Dear Mr. Chilton:

The California Department of Fish and Game (CDFG), has completed a review of the Lake Tahoe Aquatic Invasive Species Management Plan (Plan). The need for coordination between federal, state, and regional stakeholders to develop management strategies in the Lake Tahoe Basin to prevent and control aquatic invasive species (AIS) should be a prime concern for all stakeholders. The development of the Plan will help facilitate the coordination of all interested parties to prevent and control AIS. As a participating agency on the Lake Tahoe Aquatic Invasive Species Coordination Committee (LTAISCC), and the Lake Tahoe Aquatic Invasive Species Working Group (LTAISWG), CDFG is submitting comments to help facilitate the completion of the Plan and to ensure coordination with California Department of Fish and Game codes and policies - in particular the California Aquatic Invasive Species Management Plan (CAISMP). The Department's comments on the draft Plan are as follows:

The Plan should be consistent with format, goals, and objectives of the CAISMP. Although the Lake Tahoe Plan will have specific species, management, or formatting differences from the CAISMP the overall management framework and objectives should be consistent with the CAISMP.

The Introduction section and glossary should have clear definitions of what the plan is considering and covering as an AIS. The Plan needs to explicitly state the difference between an AIS and a non-native or non-indigenous species. Many non-native or non-indigenous species were introduced as part of a historic resource agency or societal value management strategies. All tables, figures, and the body of the text need to be consistent in what is being defined as an AIS and what is being defined as a non-native or non-indigenous species. The CAISMP has a clear definition of AIS and non-native or non-indigenous species on page 1 of the introduction section and also page ix in the glossary.

Conserving California's Wildlife Since 1870

Mr. Chilton
April 8, 2009
Page Two

The plan should incorporate and reference a rapid response plan (RRP) that should be included as an appendix. The RRP should designate lead and/or cooperating agencies for implementation of a rapid response. CDFG recommends an incident command system (ICS) which was recently integrated into the National Incident Management System (NIMS). The ICS was developed to allow staff from different government organizations and agencies to work together to respond to a particular problem. For reference, the CAISMP has a RRP included as Appendix A.

Questions or comments should be directed to Mr. Jason Roberts, Environmental Scientist, at (916) 358-2895 or jdroberts@dfg.ca.gov, or Mr. Stafford Lehr, Senior Environmental Scientist, at (916) 358-2838 or slehr@dfg.ca.gov.

Sincerely,

Sandra Morey
Regional Manager

ec: Stafford Lehr
Jason Roberts
Kevin Thomas
Toni Pennington

California State Lands Commission (CSLC)

C: Page E-2, Objectives – Should the list of objectives be alphabetized since Section 6.0 (Table 5) has the objectives alphabetized?

R: Done

C:Page 3, Figure 1 – Recommend including and labeling Amador and Alpine counties that are adjacent to El Dorado County.

R: Changed figure

C:Page 4, 1st ¶ – Change sentence to: "Both the Upper and Lower Truckee Rivers are home to the federally threatened Lahontan cutthroat trout . . ."

R: Done

C:Page 4, 2nd ¶ – Recommend changing to: "Land ownership in the Tahoe Basin is largely managed by the USFS with three state parks on the California side and two state parks on the Nevada side (Figure 1).

R: New language recommended by CADPR

C:Page 27, Table 4 – CEQA would probably apply to control, eradication, and prevention where certain actions on the California side would have potential environmental impacts.
R: Added "X's"

C:Page 42, Table 6, Strategy E2c – Add California State Parks (CSP) to Coop. Entity. Also, this action was specific to Emerald Bay and Ski Run, at least for removal.
R: Added CADSP (acronym per their request)

C:Page 50, 11.0 Glossary – Glossary seems limited—would think many other terms could be added.
R: More added.

C:Page 9, 4.4 Signal Crayfish – A potential question is there have been observations of massive die-off of signal crayfish along the west shore of Lake Tahoe sometimes in the hundreds at one time. What is the cause of such massive die-offs?
R: Suggestion taken

C: Page 6, Table 3 – Should phone numbers also be included as they are in Tables 2 and 4? Should phone numbers be included at all? Not sure everyone wants them listed. Preference?
R: Discuss with LTAISCC

C: Page 14, Lake Tahoe AIS Working Group (LTAISWG) – Has the 2007 Memorandum of Understanding (MOU) been signed by the stakeholder group members? Should the MOU be included in the LTAISMP as separate Appendix?
R: MOU added

Lahontan Regional Water Quality Control Board (LRWQCB)

R: Numerous comments provided by the LRWQCB, namely related to Basin Plan language (see Appendix A)

Nevada Department of Wildlife (NDOW)

C: NDOW's NRS related to enforcement is section 500

R: Changed text to: " In Nevada, the Nevada Department of Agriculture (NDA) is the lead agency for regulatory activities associated with noxious weeds and the Nevada Department of Wildlife (NDOW) is the lead agency for regulatory activities associated with prohibited wildlife. Under NRS Title 14 Chapter 171.123, any peace officer (e.g. NDOW Game Warden, county sheriff deputy, city police agencies) may detain a person that has committed, is committing or is about to commit a crime (e.g. possession of state listed prohibited wildlife [NAC 503.110] or plant [NAC 555.010] species). Additionally, NDOW Game Wardens (or other Nevada peace officers), as deputies of the USFWS have the authority to uphold provisions of the Lacey Act."

C: NDOW has two documents in draft form, "Prevention and Disinfection Guidelines" and "Quagga Mussel Monitoring Program". Due to the vacancy in the Endemic fisheries staff Biologist position the programs have been slow to proceed. I would like the statement "The State of Nevada does not have a well-coordinated AIS program…" re-worded. It reflects that NDOW is not onboard with the basins efforts. Once the position is filled the State AIS plan will be the positions priority.

R: Changed text to: "The State of Nevada has completed draft guidance to prevent and monitor for AIS, particularly quagga mussel. Once a key staff position is filled, "Prevention and Disinfection Guidelines" and the "Quagga Mussel Monitoring Program" will be top priorities."

C: "Other game fish managed by NDOW include kokanee salmon and golden trout" – While golden trout were stocked into Lake Tahoe in the early 1900s, their establishment was not successful and there is currently no management of this species in the lake.

R: Changed text to: "As defined by NDOW (NAC 503.060) coldwater game fish include: brook trout, brown trout, lake trout, and rainbow trout. Kokanee salmon is also managed by NDOW as a game fish." Scientific names referenced in Table 2.

C: ***Game*** fish in Marlette Lake include brook trout, Lahontan cutthroat trout and rainbow trout … (cuttbows hybrids are not present). There are other native non-game fish present as well.

R: Changed text to: "Marlette Lake, located in the Lake Tahoe Nevada State Park northeast of Lake Tahoe, is closed to motorized watercraft. Game fishes in Marlette Lake include brook trout, Lahontan cutthroat trout, and rainbow trout. The lake is currently managed as a brood lake for rainbow and cutthroat trout which provide eggs for NDOW hatcheries."

C: Spooner Lake is stocked not only rainbow trout, but other types of trout as well (brown, hybrid rainbow x cutthroat, and hybrid brown x brook 'tiger trout'). Maybe the statement should read: "it is open to catch and keep trout fishing with a five trout limit."

R: Suggestion taken

C: State of Nevada and NDOW [economic] impacts due to AIS could be reflected as well. The department's hatchery system, sports fishermen impacts due to stocking limitations, NDOW staff specialists programs to reflect AIS issues, Wildlife commission. It will take a little while but I may be able to place a number to the impacts to Nevada's sporting tourism base. Fishermen spend roughly $250 million dollars a year fishing Nevada (Commission Policy P-33) per a 1996 study.

R: Changed text to: "In Nevada, anglers spend roughly $250 million a year (Commission Policy P-33) and NDOW is particularly concerned about the impacts of AIS on the hatchery system and subsequent limitations on stocking capacity. As an example, the Lake Mead Hatchery is currently closed due to quagga mussels in the source water (Lake Mead). Until an alternative water source is provided or decontamination procedures are developed, other NDOW hatcheries and a USFWS hatchery are making up for reduced fish production."

C: The following sentence should be added to the end of the last paragraph: "Fish used as live bait may be taken only from, and must be native to, Lake Tahoe and its tributaries".

R: Added

C: NV AIS Mgmt Plan – It is true that NV does not have an AIS management plan, however we do have some component of such a plan in draft form ("Quagga Mussel Monitoring Program" and "Prevention and Disinfection Guidelines").

R: Changed text to: "Even though Nevada is currently without an ANSTF-approved AIS plan, NDOW currently has draft versions of the "Quagga Mussel Monitoring Program" as well as "Prevention and Disinfection Guidelines". The Arizona Invasive Species Advisory Council recently released *Arizona Invasive*

Species Management Plan 2008 in which the impacts and prevention of AIS are addressed. The absence of a plan from Nevada, an important recreational state where quagga mussels are found in Lakes Mead and Mojave, leaves the Tahoe Basin particularly vulnerable to AIS introduction."

C: Attachment D-1: LTAISWG Memorandum Of Understanding-----I recommend that the Attorney General's Office review the MOU prior to any official signatures.

R: Noted – this should be brought to the attention of the LTAISWG

C: Attachment D-2: Letter In Support Of Forming The LTAISCC-----NDOW is referred to as Nevada Division of Wildlife.

R: This letter was drafted by TSC.

C: Appendix E: Potential Economic Impacts-----fails to mention loss of revenue to NDOW from a decrease in boat registrations and motor boat fuel tax, which will result in less federal US Coast Guard grant money to Nevada.

R: Noted – should be addressed in the next draft.

C: Table 3 – Spooner has a fair amount of nonmotorized boating (and the occasional electric motor). Therefore, there should be an "x" in the nonmotorized boating column.

R: added 'x'

C: Page 53 – the text reads: "… quagga mussels are present in the Lower Colorado River lakes (Lake Mohave AZ/NV; Lake Havasu, CA/AZ; Copper Basin Reservoir, CA), at the Nevada State Fish Hatchery (Lake Mead) …" . This statement implies that the hatchery is currently infested, which it is not. The Lake Mead Hatchery has been decontaminated and is presently void of trout while NDOW is pursuing an alternate water delivery system with the Southern Nevada Water Authority. The water delivery system will be modified to provide treated water (quagga mussel free) to the facility.

R: Changed text

Nevada Division of State Lands (NDSL)

C: E-2 /p5 both second paragraphs – Although there may not be a specific NRS or a complete AIS plan in Nevada I have had conversations with David Catalano(NDOW) regarding a policy statement or initiative from the Wildlife Commission (P33) which I think could be referenced in these sections. This also indicates to me that there is a stronger potential to develop a comprehensive plan in the future.

R: Text added to acknowledge anticipated Nevada AIS management plan

C: p2 first paragraph – The division of State Lands also owns and manages approximately 500 urban parcels in the Basin.

R: Added

C: p52 Table 6 - State Lands (through its license plate program [Nevada Lake Tahoe License Plate Fund) is also providing an additional $154,000 for work associated with the Asian clam removal study pilot project . A proposal for approximately $80,000 to also conduct research related to this project has rank well through the License plate TAC process.

R: Added to Table 9 and Figure 12

C: P59 Table 7 NDSL should have "X" s by coordination and financial assistance. NDSP should have "X"s by Coordination, Education/outreach & prevention

R: Added

Tahoe Science Consortium (TSC)

C: List goals and identify how objectives meet those goals

R: Added goals to Executive Summary

C: Provide hints for how this document should be used and how to ensure it will remain current/relevant.

R: Included an action item (name) to establish a LTAISCC Review Sub-committee responsible for reviewing the Plan and making necessary updates at least every five years. Additionally, encouraged interaction between the LTAISCC and other state, federal and international AIS groups to improve information exchange.

C: Part of the Purpose ought to be to help facilitate achieving the goals and objectives stated in the Plan

R: Added more descriptive language, i.e., …to facilitate coordination of regional, bi-state, state, and federal programs and to prioritize and guide implementation of AIS prevention, monitoring, control, education, and research actions in the Region.

C: There is a subtle but important issue here. The State needs to appoint a water body an ONRW, and I think EPA has the ability to concur. CA has appointed Lake Tahoe an ONRW but NV has not.

R: … the lake is designated an Outstanding National Resource Water (ONRW) under the Clean Water Act (1972) by the California Regional Water Quality Control Board. Likewise, Lake Tahoe is designated a "water of extraordinary ecological or aesthetic value" by the Nevada Division of Environmental Protection.

C: Check historical Secchi depth records

R: 36 m

C: Regarding Figure 1, I recommend not identifying land ownership, unless there is some sort of requirement to do so. Ownership is changing. Also, this figure does not show the thousands of small lots owned by the LTBMU and CTC, which exist within the tracks of private ownership. This is inaccurate information. Land ownership in the Tahoe Basin is managed by the various land owners, not the USFS. The USFS is a major land owner. There are more than 3 state parks on the CA side of the Lake. There are also State Parks on the NV side of the lake.

R: Changed Lake Tahoe Basin map to: TRPA Compact definition of Lake Tahoe Region

C: "to coordinate state programs, create a statewide decision-making structure and provide a shared baseline of data and agreed-upon actions so that state agencies may work together more efficiently". This ([from the CAISMP] seems like a really good purpose. How come the Lake Tahoe AIS plan doesn't include this purpose?

R: The purpose of the *Lake Tahoe Region AIS Management Plan* (the Plan) is to facilitate coordination of regional, bi-state, state, and federal programs and to prioritize and guide implementation of AIS prevention, monitoring, control, education, and research actions in the Region.

C: This diversity, in addition to the ONWR designation of Lake Tahoe, enforces the need for a focused regional AIS management plan (as defined by the ANSTF). Regional AIS prevention activities have been implemented by the TRPA and Tahoe RCD; however, there is no overriding guidance in the Basin to prioritize, maintain funding, and implement AIS management efforts.

R: Added language

C: Do you want to mention outside review of the economic information?

R: Added language

C: In reference to: "The Lake Tahoe Region is home to approximately 75,000 permanent residents and has drawn over three million visitors every year for over a decade." Do you have a reference to support these facts?

R: Citation added

C: In reference to: "…it should be noted that the [economic] results have associated uncertainty. The analysis applied the conservative end of identified ranges of potential damages in an effort to not overestimate potential damages." Can you quantify this uncertainty? If so, then I would include standard deviations or other measures of variance along with the averages. If not, then I would consider reporting ranges rather than averages.

R: Information based estimates of best available information

C: In reference to: Figure 8: Potential Average Annual Impacts of AIS at Lake Tahoe over 50 Year Period: This figure is redundant with the last column in Table 2. I'd add the percent values to the last column in table 2 and delete this figure.

R: Done

C: In reference to: "Because the presence of AIS has the potential to significantly impact the regional economy, the merits of investing in prevention, control, and eradication measures cannot be understated". You can't really say this unless you tell us what the total regional economy is. I have heard the annual regional economy is in excess of $1 billion/yr. $22.4 million is then 2.2% of the annual regional economy. This is not a significant value.

R: Sentence deleted

C: In reference to: A1b. Identify lead organization for Plan oversight. I'm not so sure that TRPA alone is best suited for plan oversight. Given FWS role, I would say oversight should at least be co-led by TRPA and FWS. This is something the coordinating committee should consider.

R: LTAISCC agreed TRPA should be lead as they are a regional bi-state agency with regulatory authority.

C: In reference to: A1e. Fiscal commitment to Plan implementation. What level of fiscal commitment is needed to implement this Plan?

R: TBD

C: In reference to A.2D; The first sentence in this section says the review committee with conduct this review. This is not an external review. I'd recommend that the plan undergo revision every 5 years based on needs identified in the internal review. The resulting revised plan should then undergo internal and external review.

R: LTAISCC agreed, external review will occur as needed

C: In reference to A.3A, Seems like the same subcommittee could perform the actions under 3a and 3b. Given the length of text, I'd combine these sections and describe in a bit more detail how the subcommittee will go about identifying "items" for funding. Are these items projects, capital investments, education, or?

R: Agreed; combined

C: In reference to F1, Eradication is different than long-term control and management

R: Agreed, clarified in AIS Management Framework

C: In reference to Science Research projects "Continue warm water fish research" I'd say this needs a bit more vetting. From what I'm hearing, studying the effectiveness and impacts of various Asian clam removal strategies is a very high priority.

R: Priorities based on LTAISWG discussions

C: Future revisions of the Plan by the Coordination Committee should fully address issues. What issues?

R:

C: What is the means of distribution for Asian clams to other locations in the lake? Seems like we know the answer to this: passive movement of veligers via currents and mechanical (human) movement of established clams.

R: Added suggestions

University of California at Davis, Tahoe Environmental Research Center (UCD-TERC)

C: In reference to, "Invasive invertebrates threatening introduction to the Basin include zebra mussels (*Dreissena polymorpha*), quagga mussels (*D. bugensis*) and New Zealand mudsnails (*Potamopyrgus antipodarum*). I'd consider other invertebrates here. You probably had a system for determining the big three, but Spiny Waterflea is one I'd get on there. The Minnesota Sea Grant web page has a great summary of aquatic invertebrates, and I think it'd be precautionary yet prudent to consider some of those species too.

R: Added

C: "She also found that 117 boats had aquatic plants (native and non-native) attached and that 82.1% of boaters surveyed "never" conduct as much as a visual inspection of their equipment after use. " The difference here is between visual inspection specifically for plants and the "do nothing" for cleaning refers to boat care specifically, with no intent for AIS.

R: So noted

C: "The larvae are released through the excurrent siphon as active juveniles and can resist some of the currents that would carry them away from suitable habitats." More importantly, during a short pelagic period, they can be passively transported relatively long distances. This is more of an invasive life strategy than being able to stay put, I think. Also makes them more of a within-lake threat.

R: Added

C: "And, based on calcium and pH in Lake Tahoe, it has been determined that zebra mussels have "low or no colonization potential" (Cohen and Weinstein 1998). True. But, in light of the new granby information—which is certainly preliminary, I think it'd be good not to push this 12 mg L number too hard. There are other variables that should be considered alongside Calcium requirements

R: See below for related comment/response

C: "Factors that influence the survivability of invasive aquatic invertebrates include temperature, moisture, calcium concentration, food quantity/quality and pH (Sprung 1987, Ramcharan et al. 1992, Mellina and Rasmussen 1994, Cohen and Weinstein 2001; Wacker and von Elert 2003)." Food availability! There's an abundant literature showing zebra/quagga crashes once they've effectively filtered out the phytoplankton. This should be considered here…especially given Lake Tahoe's primary production

R: Added "food availability"

C: "It is estimated, however, that dreissenid mussels require a calcium threshold greater than 12 mg/L, thus Lake Tahoe is not currently considered vulnerable to colonization by quagga or zebra mussels (Cohen 2007)." This statement needs revision. This number is not necessarily hard and fast…must also consider food availability, pH, etc.

R: Added text to emphasize these limitations.

C: There is not evidence that the calcium would facilitate the establishment. There is evidence that Asian clam beds provide areas of increased calcium concentration. And there is evidence that there is a positive relationship between mussel presence and calcium. But the link that these Asian clam beds + increased establishment has not yet been made. Please reword.

R: Changed language

University of Nevada at Reno (UNR)

C: I am confused about this table [Table 2]. Does Y mean they are in the watershed or that are worried about them? This should be more specific. Where are there mudsnails in the basin?

R: Y = intentionally introduced; presence of New Zealand mudsnail in the Tahoe Basin was a typo

C: [Bluegill Life History] I am going to send you our NSL report that talks about the feeding, age, etc of bluegill in the Tahoe keys. You may want to use this for this section or let me know and I will have Christine our staff person rewrite this section for you. We actually have a lot of diet and age data for these fish from Tahoe (Tahoe Keys at least) that could be used here.

R: Added text on bluegill and largemouth bass diets in Lake Tahoe based on Chandra et al. 2009

United States Department of Agriculture – Agricultural Research Services (USDA-ARS)

Numerous comments were provided by the USDA-ARS as part of the Plan review sub-committee.

C: Regarding comment above, I agree- this especially important regarding “prevention” strategies. Site Marion’s work and the recent “finds” on mussels on boats “just before launching”

R: Added

C: In reference to: “Because the presence of AIS has the potential to significantly impact the regional economy, the merits of investing in prevention, control, and eradication measures cannot be understated”. If you include the dreissenid mussels and further expansion if they are not kept out of Tahoe, this figure ($) could rise dramatically. I’d leave in this statement.

R: So noted

C: In reference to table 3,This table under states real funding – it should include “in-kind” dollars from a large number of agencies (including USDA-ARS) that allocate staff, facility, travel, etc. to this effort. Is that what the bottom part of the table is? If so, you’ve omitted USDA (ARS and Forest Service)
I think we should put is some $$ here

R: Added

C: Above comment [“Eradication is different than long-term control and management”], I agree w/ Zach- but you can spell out these differences in the intro. text. We should have a brief discussion of the need to get to details of actions for eradication vs.” management”. Often the methods are similar but applied differently, or are used in a fully integrated “eradication” mode.

R: Language added

C: Might want to include aquarium trade/hobbyists (not just aquascaping). You can cite the paper on aquarium trade, etc. This goes for fish and plants!

R: Done

United States Forest Service – Lake Tahoe Basin Management Unit (USFS-LTMMU)

C: “Bullfrogs were first collected in Lake Tahoe in 1948 near Taylor Creek Meadows (USGS 2008). Local ESA listed species that have been impacted by the bullfrog include relict leopard frog (*Rana onca*) (Bradford et al. 2004) and California red-legged frog (*Rana aurora draytonii*) (Lawler et al. 1999. Doubledee et al. 2003).” Relict leopard frogs and red-legged frogs are not native to Lake Tahoe basin. However, historic records indicate that Sierra Nevada yellow legged frogs (formally mountain yellow legged frogs) were found in Fallen Leaf Lake, Tallac Creek, and I would assume in Taylor Creek.

R: So noted

C: You are already in receipt of our recommended changes regarding wildfire resource guidelines (from Richard Vacirca 5/26/2009 07:37 AM). You are also receipt of our recommended changes regarding developed recreation sites (from Richard Vacirca 5/27/2009 12:05 PM). We have a few additional comments to consider for finalization:

- It would be helpful to provide greater emphasis on encouraging adaptive management of the AIS Management Plan; specifically, there may be some merit in considering higher levels of protection / control for certain lakes (e.g., those at present free of invasive species). We would favor an incentive-based approach over an enforcement approach, whatever direction the adaptive management would lead technically.

R: Additional text added

- The AIS Management Plan does not fully address dispersed recreation, due to the scope of the problem relative to the staff and funding that are likely to be available to address this issue in coming years. It also does not fully address small watercraft , though it does note that LTBMU (alone) rates screening small watercraft high (implementation table entry "C1c" on p. 95). The potential resource impact of these two factors combined (small watercraft are the most common watercraft in use in dispersed recreation) is highly problematic, as currently it is largely through public education efforts that protection against them is afforded under the Plan. This combined impact might be highlighted as a reason that the Plan may quickly evolve to increase protections as the implementation of the Plan rolls forward and we learn more.

R: Added language to Section 8 Plan Review

C: You should be aware that we are developing LTBMU's AIS Strategy with due consideration of the above and we are also giving a good deal of attention to Rapid Response protocols.

R: So noted

APPENDIX E POTENTIAL ECONOMIC IMPACTS

Travis Warziniak, University of Heidelburg

C: Overall I thought the chapter on economic impacts is good. It is well written, the report is comprehensive, and the numbers are well within plausible ranges. The information is presented in a manner that is readable to policy makers

R: No response

C: Throughout the document the distinction must be made clear between impacts from invasive species and potential impacts if new invasive species are established. In this respect, there is no base for policy comparison. This is a major flaw in the document and must be addressed. A possible distinction could be: The current AIS have caused $X in damages. If the following AIS establish themselves, we expect an additional $X in damages. Policy options include: getting rid of all currently established AIS (this will restore the $X in current damages), preventing introduction of new AIS (preventing $X in future damages), or both (restoring $X and preventing $X).

R: The report has been clarified to clearly note that all estimated damages are forward looking. That is, they are estimates of future damages if AIS are allowed to spread beyond their current status at the lake or new AIS are introduced. This allows direct comparison to future expenditure streams for AIS management to compare future costs and potential future benefits. Policy options presented in Management Plan involve prevention, detection, and control.

C: “The purpose of this appendix is to estimate the potential impacts of AIS infestation...” – so are you measuring damages from present or future invasions.

R: Revised sentence to read: "The purpose of this appendix is to estimate the potential future economic impacts of further AIS establishment and new AIS infestation in the Lake Tahoe Basin to inform policy makers of the merits of investing future financial resources in AIS management. "

C: “The largest impact category was” – do you mean “is”, “will be”.. again , current or future AIS.

R: Revised text to address comment. (TO: The largest impact category in the analysis of potential future AIS impacts was lost property values, accounting for 38% of the total estimated AIS damages.)

C: Lost recreation values – currently established AIS cannot cause future decline in recreation and visitation, so this must be talking about introduction of new species?

R: Revised text to address comment. Considering Lake Tahoe as a whole, existing AIS species have not established themselves to the extent that they would be expected to have significant affects on the categories of recreation described.

C: Does the 1.6% growth rate assume future introductions of AIS? What is our reference state of the environment for these projections?

R: No, this is using a TRPA projection assuming lake conditions remain relatively stable with current conditions. The estimates of losses to follow show the reduction in visitation that could be expected as a result of further AIS establishment and future infestations. Revised text to address comment.

C: The phrase ‘annual equivalent value” is often used before a definition is given. This is not something people will understand right away, or at least why this would differ from annual costs. For example, on E-2, “The analysis resulted in ... fifty year period .. present value of $32.6 million... annual equivalent value of $1.76 million...” Most readers would ask why the annual damages are not 32.6/50, especially on page E-3 when you give actual annual costs and it differs from the AEV.

R: Revised text to address comment. Added footnote to first page of executive summary defining "annual value".

C: The difference should be made clearer, and perhaps early in the document, between recreation and tourism. I think I figured it out late in the paper, but wondered for several pages.

R: Revised text to address comment. Added footnotes to executive summary for tourism and recreation definitions in the documents.

C: Multiple activities – How many visitors participate in multiple activities? Does a 12 percent decline in fishing and a 12 percent decline in beach activities mean a 12 percent total reduction or a 24 percent reduction or .. ?

R: Revised text to clarify that no data was available to quantify substitution of activities. As noted in the text, the estimated declines in each activity were used to inform the identification of a range on reasonable reduction scenarios. We consistently stayed on the conservative (low) end of estimates of reduced visitation to acknowledge that substitution would likely occur.

C: Population growth – You have made the case that AIS will cause property values to fall and the area, in general, to become less attractive. Are the population growth estimates assuming no AIS? maintaining current levels of water quality? Lower population growth would imply lower property values. But lower property values may also lead to increased population growth.

R: Revised text to clarify that the population projections used were based on trends, and they did not attempt to account for indirect effects on population growth due to future conditions of the lake. No data is available to correlate changes in future populations to presence of AIS in the basin.

C: There is quite a large difference in estimates of economic losses, from $120 billion to $96.9 billion. You should either pick the one you have the most confidence in or discuss why the studies come up with such wide ranges. Which one do you think is right?

R: Insufficient documentation in the referenced studies to judge the appropriateness of one methodology over another. The point of referencing these studies was to provide a backdrop of the potential effect of AIS on the nation as a whole. The values or any data from those two referenced studies were not applied in this study for Lake Tahoe. Text was added to paragraph to identify some of the basis for the differences in the two.

C: Recreation – Data from visitation was used to estimate lake-related visitation. You are missing resident use of the lake, making your estimate a lower bound. Also regarding residents, does the change in property values capitalize the change in value to docks and resident fishing, swimming, etc? I personally do not know the answer, but it's a good question. Would the price of a home decrease by roughly the same amount as the damages done to the house's dock and the loss in value of the homeowner's enjoyment of the lake?

R: Added the following footnote: "Given the methods by which the above agencies collected their visitation data, it was not possible to disaggregate visitation from regional residents and visitors who came from outside the region. As such, the data used in this analysis includes both resident recreation participants and visiting participants. The number is considered conservative because it does not include resident boaters who do not access the lake via public parkland."

C: Assuming it is reasonable to expect at 10-20% reduction in beach activities, what are the substitutes? other lakes? other activities within the Tahoe area? Is a 10-20% reduction in beach activity equivalent to a 10-20% reduction in area economic activity?

R: No, a 10-20% reduction in beach activity does not equate to a 10-20% reduction in area economic activity. The reduction in area economic activity would be some fraction of the activity participation reduction that could not be determined using available data. This is why the overall estimates of potential recreation visitation reductions apply to total basin-wide recreation visitation and are conservatively less than reductions specific to any one activity in an attempt to account for substitution. Added sentences to explain that the lack of available data forced us to estimate overall (basin-wide) reductions in visitation that might stem from the activity-specific reductions that we estimated.

See also response to comment 4.

C: Property values – How do you place a value on public property? My guess is that if a parcel adjacent to public land is selling for $1.46 million per acre, the public land is also valued near $1.46 million per acre. It does not make sense that the public parcel would be valued at $19,200 per acre. The value of land is determined in a market setting. The value of public land is its opportunity cost, that is, the value it would be sold at if it were available to be sold.

R: Revised text to address comment. Stated that average values per acre of private and public property were computed from assessors data which may underestimate the public lands since its not being assessed for tax collection purposes. We added text showing value if we assessed the public property at the private rate. Then states that in order to take a conservative approach, approach using assessor's data on public land values was carried forward in the analysis.

C: Property values and taxes – Property values will fall for parcels off the lake as well, leading to further losses in property taxes in the community. You should mention this and emphasize that numbers based on lakefront property will be a lower bound (a very lower bound) on lost property tax receipts. Someone may also raise the issue of using property taxes as an impact (also on pp 20-21). Homeowners would probably enjoy lower property taxes (I know, this is an argument for prevention aimed at local governments.) And technically, taxes are a transfer from one homeowner to other homeowners in the Lake Tahoe region (whoever gets the benefits from programs financed by tax revenues). Transfers are neither a cost nor benefit at the regional level (This is an academic argument and one that I have never found shared with community stakeholders.)

R: Added text at end of section to state that this analysis is a lower bound. Comment acknowledged, as the audience is largely government entities that would fund AIS management, the impact to the existing tax structure seemed relevant to include in the report.

C: Management costs – What does the funding do? What are current policies? Are there any success stories associated with spending $2.5 million?

R: Discussion of ongoing prevention and management activities are presented in the Management Plan Main Document.

C: You should at least address the issue of water clarity. First, it is not clear how current AIS affect the water quality. Second, if this is of primary concern, you should mention that this is actually a benefit of allowing zebra mussels to colonize. I have found in my work someone always brings up this 'attribute' of zebra mussels. It seems easier to state this upfront rather than defend its exclusion later on.

R: See comment #9. Effects of AIS on clarity are addressed in main body of the Management Plan relative to each species.

C: Jon Bossenbroek has done work on suitability of various Western lakes as zebra mussel habitat, as well as calculated some probabilities of invasion. This may be good to include in the report. I do not know if he specifically studied Lake Tahoe.

R: Thanks. Good information. While the information does not fit well into the framework of the economics analysis, it has been passed on and will be reviewed for incorporation into the main document.