5 FISH AND AQUATIC BIOLOGICAL RESOURCES

5.1 INTRODUCTION

This chapter describes the existing conditions in the shorezone area with respect to fisheries and aquatic biological resources and identifies the potential environmental impacts that could result from implementation of each of the four Shoreline Plan alternatives. The fisheries and aquatic biological resources of the Tahoe Region are an integral part of Tahoe's natural environment. This chapter evaluates the effects of implementing the Shoreline Plan alternatives on prime fish habitat, disturbance during spawning, substrate removal, obstructions to fish migration, native riparian vegetation removal, introduction of invasive aquatic weeds related to boating activity, and disruption of littoral drift processes.

Relevant comments received during public scoping included concerns about native fish population decline and loss of fish habitat.

The evaluation of fisheries and aquatic biological resource impacts were based on a review of documents pertaining to the Lake Tahoe shorezone and lakezone, including scientific studies and TRPA regulations and planning documents.

5.2 REGULATORY SETTING

5.2.1 Federal

U.S. FISH AND WILDLIFE SERVICE

The U.S. Fish and Wildlife Service (USFWS) is charged with the responsibility to protect, preserve and, if possible, enhance the nation's fish, wildlife, and related ecological resources for the benefit and utilization of the people of the United States. In fulfilling this responsibility, one of the USFWS functions is to review proposals for the erection of structures in navigable waters of the United States to ensure that fish and wildlife resources and their habitats receive due consideration in the decision-making process and the public's interest in fish and wildlife resources, and in the uses of these resources, are protected. Authority for USFWS review of such proposals originates from the Fish and Wildlife Coordination Act (16 U.S. Code 661 et seq.). USFWS is also responsible for the status of wild populations of flora and fauna and for the identification of those that are in danger of extinction, pursuant to the federal Endangered Species Act of 1973 (ESA), as amended (16 U.S. Code 1533). Permits from, or consultation with, USFWS is required for most actions that may affect listed threatened or endangered species.

U.S. ENVIRONMENTAL PROTECTION AGENCY

The Clean Water Act (CWA) gives the U.S. Environmental Protection Agency the authority to implement programs to protect surface water quality in the United States. The statute employs a variety of regulatory and nonregulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water.

U.S. FOREST SERVICE

The Lake Tahoe Basin Management Unit (LTBMU) manages approximately 75 percent of the land area within the Tahoe Region including approximately 14 shoreline miles (approximately 19 percent of the shoreline). In total, approximately 45 percent of the shorezone is managed by government agencies (federal, state, county, and city). The LTBMU Forest Plan (2016) guides the management of U.S. Forest Service (USFS) lands. The purpose of the Forest Plan is to direct the use and protection of resources, fulfill legislative requirements, and address local, regional, and national issues. USFS annually updates a sensitive species list that identifies additional plants and animals that are not federally listed as threatened or endangered but require additional consideration. USFS manages these species to prevent the federal listing of such species. USFS abides by Section 7 of the ESA. This act directs federal agencies to ensure that actions authorized, funded, or carried out by the federal government are not likely to jeopardize the continued existence of any threatened or endangered species, or result in the destruction or adverse modification of their "critical habitat."

U.S. ARMY CORPS OF ENGINEERS

The U.S. Army Corps of Engineers is responsible for compliance with Section 404 of the CWA. Section 404 establishes a requirement for a project applicant to obtain a permit before engaging in any activity that involves any discharge of dredged or fill materials into waters of the United States, including wetlands. The ESA directs all federal agencies to work to conserve endangered and threatened species and to use their authorities to further the purposes of the act. Section 7 of the act, called "Interagency Cooperation," is the mechanism by which federal agencies ensure the actions they take, including those they fund or authorize, do not jeopardize the existence of any listed species.

5.2.2 Tahoe Regional Planning Agency

THRESHOLDS

Fisheries Resources

The goal of TRPA-adopted threshold standards for fisheries resources is to improve aquatic habitat important for the growth, reproduction, and perpetuation of existing and threatened fish resources in the Lake Tahoe Basin. TRPA has adopted four indicator reporting categories in the fisheries threshold category, three numerical standards for stream habitat condition, one management standard without a numeric target for instream flow, one management standard with a numeric target for lake habitat, and two policy statements for instream flow and Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) (LCT).

Stream Habitat Condition

The stream habitat threshold is a numerical standard to achieve 75 miles of "excellent," 105 miles of "good," and 38 miles of "marginal" stream habitat for streams. Stream habitat condition is assessed by percent of stream habitat in different condition classes (excellent, good, and poor). Results from 92 stream sampling events at various locations throughout the basin between 2009 and 2014 indicate that:

- 55 percent of streams are in excellent condition (considerably better than the target of 34 percent),
- 19 percent of streams are in good condition (considerably worse than the target of 48 percent), and
- 26 percent of streams are in marginal good condition (considerably worse than the target of 17 percent).

Instream Flow

Instream flow is addressed by two threshold standards: (1) a nondegradation standard for instream flow and (2) a policy statement to divert stream intakes to lake sources, both of which are in attainment. TRPA and other agencies have instituted regulatory actions and restoration projects that support the nondegradation management standard and policy statement under the instream flow indicator reporting category. A review of available TRPA permit data indicates that TRPA has permitted temporary stream flow diversion/alterations only when the ultimate project objective was stream enhancement and/or restoration.

Lake Habitat

The lake habitat threshold standard is a management standard with a numeric target to achieve the equivalent of 5,948 acres of "prime" fish habitat within the nearshore of Lake Tahoe - defined by substrate size. Prime fish habitat includes spawning habitat and feed and cover habitat. The indicator for lake habitat showed that the status is "at or somewhat better" than the adopted management targets with an "unknown" trend. Analysis of remotely sensed data collected in August 2010 and 2015 estimated that there are about 6,135 acres of "prime" fish habitat in Lake Tahoe's nearshore/littoral zone (O'Neil-Dunne et al. 2016:19), suggesting that TRPA is meeting the adopted management target of 5,948 acres.

Lahontan Cutthroat Trout

The LCT policy statement, which states that it shall be the policy of the TRPA Governing Board to support, in response to justifiable evidence, state and federal efforts to reintroduce Lahontan cutthroat trout, has been implemented and determined to be in attainment with the adopted policy statement. Support for the basin's attainment status includes a population of LCT established in the Upper Truckee River including a recently expanded restoration area. Additional restoration is underway to re-establish populations in Fallen Leaf Lake.

Vegetation Preservation

The vegetation preservation threshold is a numerical standard without numeric targets that states that the TRPA must "[p]rovide for the non-degradation of the natural qualities of any plant community that is uncommon to the Region or of exceptional scientific, ecological, or scenic value. The threshold applies to the deep-water plants of Lake Tahoe which include macroalgae, filamentous algae, mosses, and liverworts that are typically found in depths from 200–350 feet. Three indicators are used to assess the status of deepwater plant communities: 1) absolute and relative plant composition determined from (plant dry mass per unit area), 2) plant community production measured using change in dissolved oxygen with incubations in the laboratory, and 3) the depth and spatial extent of plant beds on the lake bottom as determined by divers. The indicator status is unknown due to insufficient data.

Aquatic Invasive Species

The TRPA aquatic invasive species (AIS) threshold is a management standard that states that TRPA must "[p]revent the introduction of new aquatic invasive species into the region's waters and reduce the abundance and distribution of known aquatic invasive species" and "[a]bate harmful ecological, economic, social and public health impacts resulting from aquatic invasive species." The standards include one management standard with a numerical target, and six management standards without numerical targets:

- Prevent the introduction of new aquatic invasive species into the region's waters. No new aquatic species have been documented in Lake Tahoe since the standard was adopted in 2012. This part of the standard is in attainment.

- Reduce the abundance of known aquatic invasive species. There is no established baseline against which to assess reductions in abundance. The status of this standard is unknown due to insufficient data.

- Reduce the distribution of known aquatic invasive species. The status of this standard is unknown due to insufficient data.

- Abate harmful ecological impacts resulting from aquatic invasive species. The status of this standard is unknown due to insufficient data.

- Abate harmful economic impacts resulting from aquatic invasive species. Because the harmful impacts of all AIS have not been studied or measured, the status of this standard is unknown due to insufficient data.

- Abate harmful social impacts resulting from aquatic invasive species. Because the harmful impacts have not been studied or measured, the status of this standard is unknown due to insufficient data.
- Abate harmful public health impacts resulting from aquatic invasive species. Because the harmful impacts have not been studied or measured, the status of this standard is unknown due to insufficient data.

GOALS AND POLICIES

The following describes goals and policies of the Regional Plan that relate to protection of water quality and aquatic species:

GOAL WQ-3: aims to reduce or eliminate nonpoint sources of pollutants which affect, or potentially affect, water quality in the Tahoe Region in a manner consistent with the Lake Tahoe TMDL [total maximum daily load], where applicable.

- Policy WQ-3.3: states that the implementing agencies shall restore 25% of the SEZ lands that have been disturbed, developed, or subdivided in accordance with the Environmental Improvement Program. SEZs have beneficial effects on the fisheries thresholds.

GOAL FI-1: seeks to improve aquatic habitat essential for the growth, reproduction, and perpetuation of existing and threatened fish resources in the Lake Tahoe Region.

- Policy FI-1.1: Development proposals affecting streams, lakes and adjacent lands shall evaluate impacts to the fishery.
- Policy FI-1.2: Unnatural blockages and other impediments to fish movement shall be prohibited and removed, wherever appropriate.
- Policy FI-1.3: An instream maintenance program should be developed and implemented.
- Policy FI-1.4: Standards for boating activity shall be established for the shallow zone of Lake Tahoe.
- Policy FI-1.5: Habitat improvement projects are acceptable practices in streams and lakes.
- Policy FI-1.6: Instream flows shall be regulated, when feasible, to maintain fishery values.
- Policy FI-1.7: Existing points of water diversion from streams shall be transferred to lakes, whenever feasible, to help protect instream beneficial uses.
- Policy FI-1.8: Support, in response to justifiable evidence, state and federal efforts to reintroduce Lahontan cutthroat trout in appropriate remote locations.
- Policy FI-1.9: Prohibit the release of nonnative aquatic invasive species in the region in cooperation with public and private entities. Control or eradicate existing populations of these species and take measures to prevent accidental or intentional release of such species.

CODE OF ORDINANCES

Chapter 63, "Fish Resources," of the TRPA Code of Ordinances (TRPA Code), includes provisions to ensure the protection of fish habitat and to provide for the enhancement of degraded habitat. The chapter applies to all projects and activities that could interfere with the health of fish populations in Lake Tahoe, its tributaries, and other lakes in the region. Provisions for the protection or enhancement of fish habitat shall be included for all new uses, projects and activities within fish habitat as identified by TRPA fish habitat maps or a qualified biologist. Fish habitat consists of a complex set of elements, such as spawning and nursery areas, food supply, and escape cover.

Lake habitat is protected in Chapter 63.3.1. Projects and activities conducted in the shorezone may be prohibited, limited, or otherwise regulated in prime habitat areas, or in areas and/or at times found by TRPA to be vulnerable or critical to the needs of fish. Special conditions of project approval such as restoration of physically altered substrate or limitation of construction to designated periods may be required for development in the shorezone to mitigate or avoid significant adverse impacts on habitat or normal fish activities. Habitat restoration projects may be permitted in the nearshore or foreshore. Certain activities, such as construction, swimming, or boating, may be restricted temporarily in areas where spawning activity is occurring. The physical alteration of the substrate in areas of prime fish habitat is prohibited unless approved by the TRPA. Projects and activities affecting lake fish habitat shall be referred to state and federal fisheries agencies for review and comment.

Chapter 63.4, "Aquatic Invasive Species," discusses that AIS pose a serious threat to the waters of the Tahoe Region and can have a disastrous impact on the ecology and economy of the region. The following provisions are necessary to prevent the introduction and spread of AIS. Chapter 63.4.1 prohibits the transport or introduction or AIS into the Tahoe Region; the launching of any watercraft or landing of any seaplane contaminated with AIS into the waters of the region; the launching, or attempting to launch, of any motorized watercraft into the waters of the region without an inspection by TRPA or its designee, to detect the presence, and prevent the introduction of, AIS (nonmotorized watercraft and seaplanes are subject to inspection and are included in this provision if determined necessary by TRPA or its designee); the provision of inaccurate or false information to TRPA or persons designated to conduct inspections; and the alteration, modification or unauthorized use of any inspection seal or other device used by TRPA or its designee to indicate that a watercraft or seaplane last entered the waters of the Tahoe Region.

5.2.3 California

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

CDFW manages California's diverse fish, wildlife, and plant resources and the habitats upon which they depend. These resources are to be managed for their ecological values and for their use and enjoyment by the public. CDFW is the lead agency in California for safeguarding and regulating the uses of fish and wildlife. Under Section 1602, it is unlawful for any person to substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake designated by CDFW without first notifying CDFW and obtaining a lake alteration agreement.

The California Endangered Species Act (CESA) prohibits the taking of state-listed endangered or threatened species, as well as candidate species being considered for listing. Project proponents may obtain a Section 2081 incidental take permit if the impacts of the take are minimized and fully mitigated and the take would not jeopardize the continued existence of the species. A "take" of a species, under CESA, is defined as an activity that would directly or indirectly kill an individual of a species. The CESA definition of take does not include "harm" or "harass" as is included in the federal ESA. As a result, the threshold standard for a take under CESA may be higher than under ESA.

CALIFORNIA STATE LANDS COMMISSION

The California State Lands Commission (Commission) is responsible for sovereign lands of the state and protection of the public trust over submerged land. The Commission is a leasing agency for structures lakeward of elevation 6,223 feet, the area which is subject to the public trust doctrine. The Commission is involved with the protection of California's rare and endangered wildlife and plant species through the review and analysis of discretionary projects under the California Environmental Quality Act and CESA. During the review of projects, the Commission is required to consult with CDFW. The Commission administers the state's fee ownership of the bed of Lake Tahoe from elevation 6,223 feet lakeward, and a public trust easement between elevations 6,223.0 and 6,228.75 feet Lake Tahoe datum (LTD). This easement serves the people of the State of California for the purpose of fishing, navigation, swimming, and other water-related recreation.

LAHONTAN REGIONAL WATER QUALITY CONTROL BOARD

Under Section 401 of the CWA, any project that proposes dredging or filling activity in Lake Tahoe must obtain a certificate stating the at the activity is consistent with the state's water quality standards and criteria. In California, the authority to grant water quality certification is delegated by the State Water Resources Control Board to the local Regional Water Quality Control Board.

5.2.4 Nevada

NEVADA DIVISION OF STATE LANDS

The Nevada Division of State Lands (NDSL) maintains the public trust on the Nevada side of Lake Tahoe for submerged land below 6,223 feet LTD. NDSL is a leasing agency that requires applications for structures lakeward of permanent high water, lake elevation 6,229.1 feet. NDSL request comments from the Nevada Department of Wildlife (NDOW) regarding any impacts on recreational access and fish habitat.

NEVADA DEPARTMENT OF WILDLIFE

NDOW exercises responsibilities for the management of fish and wildlife resources and their habitats for the Nevada portion of the Tahoe region. In addition, NDOW is also responsible for boating and safety on navigable waters. NDOW's navigational safety and recreational access program (e.g., angler access along shoreline) protects boaters from navigational obstacles and ensures recreational access along the shoreline. NDOW is a reviewing and commenting agency that supplies NDSL with comments recommending approval or denial of Shorezone projects within their jurisdiction; however, NDOW does not issue permits for Shorezone construction. They do issue citations for boating violations and can remove hazards to navigation within the waters of Lake Tahoe.

5.3 AFFECTED ENVIRONMENT

The Shoreline Plan has the potential to affect fish and aquatic biological resources in Lake Tahoe. The plan does not include actions or activities within the 63 tributaries to Lake Tahoe and thus would not affect tributary streams to Lake Tahoe. Therefore, discussion of fish and aquatic biological resources is limited to Lake Tahoe and does not include tributaries to the lake.

5.3.1 Ecology

Lake Tahoe is classified as ultra-oligotrophic because it contains low nutrients levels, low levels of phytoplankton, high dissolved oxygen, and excellent water clarity. The average depth of the lake is approximately 1,000 feet, with a maximum depth of 1,645 feet and surface area of 123,553 acres (Ngai et al. 2013). Since the mid-1850s, numerous anthropogenic activities such as grazing, logging, urban development, introduction of nonnative species, and dam construction have caused ecological changes to Lake Tahoe. These alterations have caused a loss of biological integrity, decreased water quality, and a shift in food web structure and composition. The lake has been intensively studied since the mid-1960s because of concerns regarding progressive eutrophication (i.e., exhibiting an increase in nutrient levels) and loss of water clarity. Although Lake Tahoe remains oligotrophic, the trophic condition is changing as evidenced by the growth and spread of aquatic plants and the increase in phytoplankton primary productivity (Heyvaert et al. 2013).

Prior to the 1800s, the food web of Lake Tahoe was limited to one predatory fish, the native LCT. Moyle (2002) reported that LCT remained abundant in Lake Tahoe and its tributary waters until the early 1930s, but by 1939 the species was extirpated from the lake. Others suggest that extirpation occurred earlier. TRPA (2016) reported that extirpation occurred around 1860. Numerous factors were responsible for the decline of LCT, including (1) unrestricted commercial and sport fishing; (2) logging, which led to degraded spawning streams; (3) diversions of water flows from spawning streams; and (4) competition, predation, and diseases from introduced lake trout (*Salvelinus namaycush*) (Moyle 2002). Lake trout, which were first introduced in 1888, have a large self-sustaining population and now occupy the historical niche of LCT (Zanden et al. 2003).

Other nonnative introductions have also affected Lake Tahoe's biological composition and caused changes to the food web. Between 1963 and 1965, approximately 333,000 mysid shrimp (*Mysis diluviana*), commonly referred to as *Mysis*, from Waterton Lake, Alberta, Canada, were introduced at various locations around Lake Tahoe in an effort to improve the food supply for lake trout (TERC 2015). The introduction of mysid shrimp has caused the decline of two native pelagic taxa (*Daphnia* and *Bosmina* spp.) (Wittman and Chandra 2015). It is also hypothesized that mysid shrimp have caused alterations to the lake's benthic invertebrate assemblages (Caires et al. 2013). Other invasive species such as Asian clams (*Corbula fluminea*) and signal crayfish (*Pacifastacus leniusculus*) have altered nutrient cycling, which has affected algal and benthic invertebrate production, and diversity with the result that crayfish dominate the benthic community (Heyvaert et al. 2013).

Nearly 30 nonnative aquatic species are now established in the Lake Tahoe Watershed (Wittmann and Chandra 2015). Although several of these nonnative species have affected the food web, the most profound food web changes are due to lake trout and mysid shrimp. Since the introduction of these species, the food web has become increasingly reliant on pelagic resources (Zanden et al. 2003). This restructuring of the food web has caused a decline in pelagic forage fish populations and development of two distinct seasonal food webs; "a near-shore food web with few top predators and an offshore/deep profundal food web" (Wittman and Chandra 2015).

Combined with habitat alteration, increased predation pressure from nonnative fishes (e.g., kokanee [*Oncorhynchus nerka*]) has caused a decrease in the number of native fish that utilize shallow water habitat near the shoreline (Zanden et al. 2003; Lemmers and Santora 2013). Predation pressure is expected to increase as climate change and local land use changes expand the amount of thermally suitable habitat for warmwater fishes (Kamerath et al. 2008). Furthermore, the establishment and expansion of nonnative aquatic plants continue to increase habitat and refugia for these nonnative warmwater fishes (e.g., bass and bluegill [*Lepomis macrochirus*]). Thus, nonnative warmwater fishes are expected to expand their distributions throughout the lake (Ngai et al. 2013).

5.3.2 Fish Species

In the mid-1800s Lake Tahoe supported eight fish taxa. As a result of introductions and extirpations, Lake Tahoe currently supports a total of 20 native and introduced fish species. The shallow water, near-shore (i.e., less than approximately 33 feet deep), assemblage of fish comprises six species; Lahontan speckled dace (*Rhinichthys osculus robustus*), Lahontan redside shiner (*Richardsonius egregious*), Paiute sculpin (*Cottus beldingi*), Tahoe sucker (*Catostomus tahoensis*), rainbow trout (*Oncorhynchus mykiss*), and brown trout (*Salmo trutta*) (Moyle 2002). However, many other young-of-the-year (YOY) fish are also found in shallow waters throughout the year. In the midwater zone of the lake, kokanee, *pectinifer* tui chub, and rainbow trout dominate the assemblage (Moyle 2002). The deep-water assemblage is comprised of lake trout, Paiute sculpin, *obesa* tui chub, Tahoe sucker, and mountain whitefish (*Prosopium williamsoni*). Although they inhabit the midwater and deep-water areas of the lake for the majority of the year, several species generally ascend tributary streams to spawn, including kokanee, rainbow trout, brown trout, and brook trout (*Salvelinus fontinalis*).

Table 5-1 Native and Introduced Fish Species Currently Found in Lake Tahoe

Common Name	Scientific Name	Native or Introduced[1]	Status[2]
Black crappie	*Pomoxis nigromaculatus*	Introduced	–
Bluegill	*Lepomis macrochirus*	Introduced	–
Brook trout	*Salvelinus fontinalis*	Introduced	–
Brown bullhead	*Ameiurus nebulosus*	Introduced	–
Brown trout	*Salmo trutta*	Introduced	–
Common carp	*Cyprinus carpio*	Introduced	–
Goldfish	*Carassius auratus*	Introduced	–
Golden shiner	*Notemigonus crysoleucas*	Introduced	–
Kokanee (sockeye salmon)	*Oncorhynchus nerka*	Introduced	–
Lahontan cutthroat trout[3]	*Oncorhynchus clarkii henshawi*	Native	FT
Lahontan redside shiner	*Richardsonius egregious*	Native	–
Lahontan speckled dace	*Rhinichthys osculus robustus*	Native	–
Lahontan Lake tui chub	*Siphateles bicolor (pectinifer* and *obesa*)	Native	SSC
Lake trout (mackinaw)	*Salvelinus namaycush*	Introduced	–
Largemouth bass	*Micropterus salmoides*	Introduced	–
Western mosquitofish	*Gambusia affinis*	Introduced	–
Mountain whitefish	*Prosopium williamsoni*	Native	SSC
Paiute sculpin	*Cottus beldingi*	Native	–
Rainbow trout	*Oncorhynchus mykiss*	Introduced	–
Smallmouth bass	*Micropterus dolomieu*	Introduced	–
Tahoe sucker	*Catostomus tahoensis*	Native	–

[1] Indicates whether the species is native or introduced into California water bodies.

[2] Status Codes:
FT = federally listed as threatened.
SSC = California Department of Fish and Wildlife Species of Special Concern.
"–": no special-status designation.

[3] Lahontan cutthroat trout are extirpated from Lake Tahoe. However, 22,000 Lahontan cutthroat trout were planted in Lake Tahoe in 2011. There is no information available indicating if any of these fish are still present in the lake.

NATIVE SPECIAL-STATUS SPECIES

Lahontan Cutthroat Trout

LCT is an inland subspecies endemic to the physiographic Lahontan basin in northern Nevada, eastern California, and southern Oregon. Once widespread throughout the basin, LCT was the top predator in Lake Tahoe's aquatic ecosystem (TRPA 2016a). However, the species now occupies a fraction of its historical habitat. LCT occur in 10.7 percent of their historic stream habitat and 0.4 percent of their historic lake habitat (USFWS 2014). In 1970, LCT were listed as endangered under the federal ESA, but in 1975, the listing was downgraded to threatened to allow for more flexible management.

As described in Section 5.3.1, LCT were extirpated from Lake Tahoe due to overfishing, habitat degradation, and the introduction of nonnative aquatic species (TRPA 2016a). Moyle (2002) reported that LCT remained abundant in Lake Tahoe and its tributary waters until the early 1930s, but by 1939 the species was extirpated from the lake. Others suggest that extirpation occurred earlier. TRPA (2016a) reported that extirpation occurred around 1860. Efforts to reintroduce LCT into the Tahoe Basin, including Lake Tahoe, are currently underway. CDFW has successfully reintroduced LCT into the headwaters of the Upper Truckee River and this population is now the only self-sustaining population in the Tahoe Basin. In 2011, the Nevada Department of Wildlife stocked approximately 22,000 LCT into Lake Tahoe as part of an effort to restock native species for recreational anglers. LCT population dynamics, seasonal habitat utilization, growth rates, and interactions with nonnative species in Lake Tahoe remain unknown (TRPA 2016a). No additional information is available regarding the persistence of these introduced fish. Thus, this impact assessment is conducted to consider impacts if reintroduction efforts result in a persistent population of LCT or if future monitoring confirms the presence of the species from the 2011 stocking effort.

LCT are open water fish and typically remain in the pelagic (open water) zone of lakes. LCT require temperatures below 22°C, pH values of 6.5 to 8.5, and dissolved oxygen greater than 8 milligrams per liter (Moyle 2002). Large LCT feed pelagically on small fish, especially tui chubs, but tend to stay close to the bottom. Smaller LCT feed on insects from the water's surface or on zooplankton. However, if neither is abundant they will feed on benthic insect larvae, crustaceans, and snails (Moyle 2002). Like other cutthroat trout, LCT is a stream spawner which spawns between February and July (USFWS 2014). LCT typically return to the same stream from where they hatched and spawn in gravel riffles. Although each fish may spawn up to five times, most females spawn only once or twice. Spawning behavior is similar to that of rainbow trout, with females digging redds and then depositing eggs into the red as the eggs are fertilized by attending males. Embryos hatch in 6–8 weeks, then fry emerge and begin feeding within 2 weeks of hatching (Moyle 2002).

Mountain Whitefish

Once one of the most abundant fish in the eastern Sierra, the Lake Tahoe mountain whitefish population is now a fraction of its historic numbers (Caltrout 2017). Large numbers were harvested by Native Americans and then commercial harvesting further affected the population. By the 1950s, populations were low in Lake Tahoe (Moyle 2002) and today, predation pressures from invasive trout and bass further threaten the population (Caltrout 2017).

Mountain whitefish move into small tributaries to spawn from October through early December at water temperatures under 11°C. Spawning generally takes place in riffles in depths greater than 2 feet where substrates are primarily coarse gravel, cobble and rocks. However, some spawning may take place in gravel in shallow water areas of Lake Tahoe (Caltrout 2017). Fertilized eggs fall in between gravel and rocks, then hatch after 6–10 weeks. Newly hatched fish spend their first few weeks in shallow backwaters but move into the lake shortly thereafter where they seek cover in aquatic plants (Moyle 2002). As adults, mountain whitefish generally live close to the bottom in fairly deep water and swim around in schools of 5–20 fish (Moyle 2002). They also remain closely associated with beds of aquatic plants and seldom move into areas devoid of aquatic vegetation (Moyle 2002). Mountain whitefish feed on benthic invertebrates such as snails, dragonfly larvae, chironomid midge larvae, mayfly larvae, caddisfly larvae, crayfish, and amphipods, and to a lesser extent zooplankton and surface insects (Moyle 2002).

Lahontan Lake Tui Chub

Lake Tahoe's Lahontan Lake tui chub population is declining. It is thought that the numerous physical and chemical changes related to the introduction of excess nutrients, sediments and pollutants entering the lake from surrounding developments, water diversions, wastewater treatment, and wetlands destruction have adversely affected the Lake Tahoe tui chub population. The introduction of kokanee and *Mysis* also have depleted zooplankton populations, an important food source to the chubs (Moyle 2002). Largemouth bass (*Micropterus salmoides*) also have contributed to the tui chub decline by preying on juveniles in nearshore rearing areas (Moyle 2002). Although actual abundances remain unknown, the population is likely quite small relative to historic numbers. The Lahontan Lake tui chub is a California Species of Special Concern because of the uncertain, but potentially declining status of the Lake Tahoe population (UC Davis 2017).

Lake Tahoe supports two subspecies of the Lahontan Lake tui chub; the pelagic form (*pectinifer*) that schools well off the bottom and the benthic form (*obesa*) that utilizes bottom waters (Moyle 2002). The benthic population feeds primarily on benthic invertebrates, whereas the pelagic population relies on zooplankton and small terrestrial insects (Moyle 2002). Tui chub spawning occurs at night, primarily in May and June, but can continue until the end of July (Moyle 2002; UC Davis 2017). Females are serial spawners, with high fecundities (Moyle 2002). Lake Tahoe tui chubs spawn in nearshore shallow waters (i.e., less than 5 feet deep) over sandy bottoms or in the mouths of streams (Moyle 2002; UC Davis 2017). Spawning activity includes large swirling aggregations, with multiple males surrounding each female (Moyle 2002). Eggs adhere to aquatic vegetation or the substrate and embryos hatch within 3–6 days. Larvae seem to concentrate in shallow, weedy nursery areas. As they grow, tui chubs spread out along the shore over both rock and sandy areas. YOY chubs of both subspecies remain in shallow water throughout the summer (Moyle 2002) then migrate into deeper waters offshore in the winter (UC Davis 2017).

NATIVE NONGAME SPECIES

Although the native nongame species that remain in Lake Tahoe have declined since the mid-1800s small minnow populations are still supported in the lake. The primary nearshore fish community in Lake Tahoe consists of Lahontan tui chubs, Lahontan redside shiners, and Lahontan speckled dace (Beauchamp et al. 1994a). These minnows represent the bulk of fish biomass in the lake (Beauchamp et al. 1994a). Nonetheless, in certain areas of the lake, such as the Tahoe Keys area, there has been a large reduction in native fish abundances (Wittmann and Chandra 2015), presumably as a result of predation by nonnative bass and sunfish.

Minnows

Lahontan speckled dace are common in the rocky benthic zone that is stirred by wave action (less than 3 feet deep) but can utilize areas down to about 80 feet deep (Moyle 2002; Ngai et al. 2010). It is rare for speckled dace to occur singly, but they avoid forming schooling aggregations except during breeding season. Lahontan speckled dace become inactive in winter and remain in rocky areas (Moyle 2002). In contrast to dace, Lahontan redside shiners are diurnal and surface oriented. Lahontan redside shiners are nearshore species that swim about in large schools close to the surface (Moyle 2002). Once water temperatures drop below 10°C the species spends the colder months inactive deep in the lake (Moyle 2002). Both species migrate to nearshore areas to spawn during early summer periods (Wittman and Chandra 2015). Some overlap in diet between Lahontan speckled dace and Lahontan redside shiner occurs, with both feeding on diptera larvae/pupa, zooplankton, and in summer months terrestrial insects. However, benthic feeding Lahontan speckled dace also rely on benthic invertebrates for their diet (Ngai et al. 2010).

Lahontan redside shiners and Lahontan speckled dace have similar spawning characteristics. Both species spawn in gravel or small rock substrate, after dark, in very shallow water (less than 8 inches deep) when temperatures are 11°C or warmer (Allen and Reuter 1996). Redsides and dace typically spawn in the shallows of the lake itself, but also use tributaries such as Taylor Creek for spawning (Moyle 2002). Lahontan redside shiners form tight swirling aggregations of 20–100 spawning fish close to the bottom (Moyle 2002). When spawning in tributary streams, both species exhibit similar behavior, swimming over the spawning gravels and releasing eggs and milt. The fertilized eggs become lodged in the substrate where they will incubate and later hatch. The newly hatched young swim down to slow water at the mouth of the spawning stream and hide in schools under cover (UC Davis 2018). Both species spawn from June through August; however, Lahontan redsides typically go through two spawns per year (Evans 1969 and Miller 1951, cited in Allen and Reuter 1996). For Lahontan redside shiners spawning typically begins in early June and a second spawning peak occurs in August (Allen and Reuter 1996). By mid-August, YOY are abundant for both species.

Sculpin and Suckers

Paiute sculpin and Tahoe suckers remain abundant in Lake Tahoe. However, their use of the lake has changed over time. Paiute sculpin were historically abundant in the nearshore environment, but recent surveys have not detected sculpin in nearshore zones (Heyvaert et al. 2013). A diet study revealed Paiute sculpin demonstrated greater reliance on pelagic food sources and reduced food web position compared to historical conditions (Heyvaert et al. 2013). As bottom feeders, Tahoe suckers feed on midge larvae, amphipods, and annelid worms from sandy environments (Moyle 2002). Those Paiute sculpin that use shallower areas of the lake also primarily feed on benthic organisms, such as chironomid midge larvae (UC Davis 2017). In contrast, deep water dwelling Paiute sculpin feed on mostly detritus and algae (UC Davis 2017). Both sculpin and suckers form a large part of trout diets in Lake Tahoe (Moyle 2002).

Paiute sculpin are generally found near aquatic macrophyte beds in deep water less than about 200 feet deep but have been collected down to about 690 feet deep (Moyle 2002; UC Davis 2017). The species is sedentary and live under rocks during the day but come out at night when it is easier to ambush and capture their prey (Moyle 2002; UC Davis 2017). The species reach sexual maturity in their second or third year, and then spawn in rocky or gravelly substrates from May to late August. However, peak spawning occurs from May to early June (Moyle 2002). Females build nests in wave-swept nearshore areas or just off the mouths of streams (Moyle 2002). After females deposit their eggs, males fertilize the eggs, then tend the nests to defend the embryos from predation (Moyle 2002). After fry hatch they remain in their nests for 1–2 weeks.

Tahoe suckers are generally found at depths less than about 50 feet, but occasionally have been found as deep as about 985 feet (Moyle 2002). Two spawning populations of Tahoe suckers occur in Lake Tahoe, one that spawns in streams and one that spawns within the lake. Lake-spawning Tahoe suckers choose rock and gravel substrate, typically at depths of about 15–60 feet, although some may spawn in shallower areas (Moyle 2002). Spawning takes place between March and August when temperatures range from 12 to 23°C (Moyle 2002; UC Davis 2017). Males first appear on spawning beds, with two to eight males attending each female (Moyle 2002). Intense spawning activity leads to creation of shallow nestlike depressions and adhesive eggs become buried in the gravel (Moyle 2002).

COLDWATER GAME FISH SPECIES

Coldwater game fish, including several species of trout, have been planted in Lake Tahoe beginning in the mid-to-late 1800s for recreational angling purposes. Lake trout and kokanee are the two most popular species among recreational anglers. Other coldwater species popular with recreational anglers include rainbow trout and brown trout. A small population of brook trout also inhabits the lake (Heyvaert et al. 2013). Sixty-three tributary creeks enter Lake Tahoe and provide permanent spawning and rearing habitat for all coldwater game species, except lake trout, which spawns in the lake (NDW 2014, 2016).

Lake trout are one of the introduced species that have most dramatically restructured the pelagic food web in Lake Tahoe (Zanden et al. 1993), but they are also an important component of the recreational fishery. The *Mysis* introduction during the 1960s corresponded with a feeding shift for lake trout, from native fishes across habitats to a primarily pelagic diet consisting of *Mysis* and pelagic forage fish (Chandra et al. 2009). During summer months, most lake trout utilize the hypolimnion (cold, deep areas of the lake), but move into more shallow waters (131–197 feet deep) for spawning during September–November (Beauchamp et al. 1992). Unlike most lake trout populations, which spawn over rocky shoals such as cobble, boulder, or broken angular rock, the population in Lake Tahoe spawns on deep-water mounds over beds of the macrophyte *Chara delicatula*. Although it is unusual for lake trout to spawn on macrophytes, strands of *C. delicatula* provide the necessary requirements for successful egg incubation and protection from predation (Beauchamp et al. 1992).

Kokanee were accidentally introduced into Lake Tahoe in 1944, but the population remained small until about 1960. Today, the State of California still regularly stocks kokanee, which remain an important summer sport fishery in Lake Tahoe. Prior to the establishment of *Mysis*, kokanee fed primarily on zooplankton. Today, the kokanee diet in Lake Tahoe is dominated by midge pupae, copepods, and terrestrial insects.

Most natural reproduction occurs in Taylor Creek (greater than 90 percent) from mid-September through mid-November (Beauchamp et al. 1994b). However, in some years spawning occurs in beds of gravel close within the shorezone (Byron et al. 1989; Moyle 2002; Allen and Reuter 1996). Eggs and alevins incubate in gravel nests (redds) until spring, when they emerge and migrate to the lake. Kokanee are widely distributed in open waters and remain close to the surface except when temperatures become too warm in August and September (Moyle 2002). When water temperatures are too warm for the fish to utilize surface waters, large schools are found at depths of 49–131 feet (Cordone et al. 1971, cited in Moyle 2002).

Rainbow trout and brown trout are widely distributed in open waters, but in the evenings, they move into shallower nearshore waters to feed on native minnows (Moyle 2002). Rainbow trout and brown trout are the primary piscivores in nearshore areas where they capture mostly Tahoe sucker and Lahontan redside, and to a lesser extent speckled dace, Paiute sculpin, and tui chub (Moyle 2002). Brook trout primarily feed on terrestrial insects, aquatic insect larvae, and zooplankton, but larger trout can become piscivorous (Moyle 2002). Although brown trout, rainbow trout, and brook trout generally spawn in creeks, in large lakes they can also successfully spawn on gravel bars close to shore (Moyle 2002). However, anecdotal evidence suggests rainbow trout spawning primarily occurs in Lake Tahoe's tributaries (CDFG 1965; NDW 2016). Available literature indicates that spawning surveys occur only in these tributaries (NDW 2016). Therefore, it is assumed that most rainbow trout spawning occurs in these tributaries.

Brown trout spawning typically takes place in October but may extend into December (CDFG 1965; Moyle 2002), brook trout spawn from mid-September to mid-January (Moyle 2002), and rainbow trout spawn from April to May (NDW 2016). All species prefer cool, clear, well-oxygenated water for spawning (depending on the species, anywhere from 4°C to 15°C). Females construct redds with their tails and deposit eggs as males fertilize them (Moyle 2002). Brook trout can spawn in a variety of environments ranging from sandy bottomed areas to piles of boulders, whereas brown trout and rainbow trout prefer coarse gravel (Moyle 2002).

WARMWATER FISH SPECIES

Generally, warmwater game fish species include nonnative fish species that are popular among recreational anglers. A variety of nonnative warmwater game fish species were illegally introduced in the mid1970s to late 1970s and again in the late 1980s (Reuter and Miller 1999). More recently, in the Tahoe Keys, smallmouth bass (*Micropterus dolomieu*) were discovered in 2011 and common carp (*Cyprinus carpio*) were found in 2012 (Wittman and Chandra 2015). Additionally, warmwater nongame fish species, including golden shiner (*Notemigonus crysoleucas*) and western mosquitofish (Gambusia affinis), also are found in the lake.

The most common nonnative warmwater species in Lake Tahoe generally, and Tahoe Keys specifically are largemouth bass and bluegill. Control efforts have been implemented to reduce nonnative warmwater fish species, but generally they continue to persist (Wittmann and Chandra 2015). Nonnative warmwater fishes primarily occur in the Tahoe Keys and Taylor Creek. However, snorkel surveys show satellite populations of bluegill and largemouth bass occur in other areas of the lake (Chandra et al. 2009, Kamerath et al. 2008). The extent of warmwater fishes in areas outside of the Tahoe Keys remains unclear, but research suggests suitable habitat has increased due to warming water temperatures and the expansion of aquatic weed beds (Kamerath et al. 2008, Chandra et al. 2009, Ngai et al. 2013). Although suitable spawning habitat for warmwater fish is available in a number of areas around the lake, the south shore provides the most overall suitable spawning habitat followed by the east shore, north shore, and west shore (Chandra et al. 2009).

Largemouth bass begin spawning when temperatures reach 15.9°C (Kramer and Smith 1960, cited in Chandra et al. 2009), and bluegill spawning begins when temperatures reach 18°C (Moyle 1976, cited in Chandra et al. 2009). Minimum spawning temperatures for largemouth bass and bluegills are generally met or exceeded between May and August (Chandra et al. 2009). Because smallmouth bass have only recently been observed in Lake Tahoe there is little available information on their life history within the lake. However, in northern California, smallmouth bass typically build nests then spawn in shallow waters (less than 3 feet) from May through June or July (Moyle 2002; Ngai et al. 2010). In Lake Tahoe, black crappie

(*Pomoxis nigromaculatus*) typically spawn from March to late June and brown bullhead (*Ameiurus nebulosus*) (a species of catfish) spawn in late April or May (USFS 2017).

Nonnative warmwater fish feed on a variety of food types. Top predators such as bass feed on native minnows (family Cyprinidae) and trout. Bass also feed on juvenile tui chub when they are rearing in nearshore areas (Moyle 2002). Brown bullhead are bottom feeders that feed on mollusks, insects, leeches, crustaceans, fish and fish eggs (USFS 2017). Common carp also scavenge bottom sediments, grubbing for zooplankton, crayfish and benthic worms. The diet of black crappie consists of zooplankton, insects, larvae, and small fish (USFS 2017). The diet of bluegill and golden shiner overlaps with native fish species and they feed primarily on mollusks, plant material, and invertebrates (Chandra et al. 2009). Western mosquitofish also compete with native species for food and are wide spectrum omnivores.

5.3.3 Aquatic Habitat

The geographic area addressed by the Shoreline Plan alternatives is the 72-mile-long shorezone of Lake Tahoe. The TRPA Code (Chapter 83) defines the shorezone as the area consisting of the nearshore, foreshore, and backshore (see Exhibit 2-2 in Chapter 2, "Description of Proposed Project and Alternatives"). Beyond the shorezone (i.e., deeper/farther from the shoreline than the nearshore) is the lakezone, which is defined as any part of the lake that is deeper than 6,193.0 feet LTD.

Because the backshore consists of land located between the highwater line of the lake and the upland area, it is not considered fish habitat because it is only intermittently wet (i.e., during wave action). Further, the foreshore is defined as the area between the high and low water lake levels, and also is only intermittently wet. However, while the backshore is intermittently wet when wave action is occurring, the foreshore is wet whenever lake levels are high.

The nearshore, foreshore, and backshore areas are defined by TRPA based on lake elevations or distances from the shoreline for planning purposes and are not necessarily based on aquatic habitat characteristics or use by aquatic species. Therefore, the areas within the shorezone that can be utilized by fish and serve as aquatic habitat are collectively referred to as nearshore fish habitat. Specifically, the nearshore (as defined by TRPA), along with the foreshore when it is wet during the higher water periods of the year are considered nearshore habitat.

Three primary habitats are utilized by Lake Tahoe fishes; nearshore habitat, tributary streams, and pelagic habitat. Nearshore fish habitat and tributary stream mouths are both located within the shorezone, whereas pelagic habitat is located within the lakezone. TRPA has implemented policies and regulations designed to protect fish habitat while also maintaining high quality recreational experiences. Habitat types and the regulations associated with them are described below.

NEARSHORE HABITAT

Although TRPA defines the nearshore specifically based on depth and distance from the shoreline, no consistent definition of a nearshore fish habitat is readily available (Heyvaert et al. 2013). The generic definition of the nearshore zone or nearshore habitat as it relates to aquatic species is to consider it equivalent to the littoral zone. A littoral zone, as it is typically used in scientific literature, is defined as the shallow area of a lake that supports macropyhte (i.e., aquatic plant) growth with "the deepest extent of the littoral zone considered that depth at which one percent or less of surface light penetrates to the bottom sediments (i.e. photic zone)" (Heyvaert et al. 2013). Due to Lake Tahoe's extreme water clarity, the 1 percent light level is very deep. Conditions in the nearshore fluctuate with precipitation, wind, and lake levels.

Nearshore habitat provides rich spawning, nursery, and rearing habitat for native fish species and is the location of the lake where highest fish densities are found. This narrow strip of lake also receives the greatest concentration of human activity, which includes intense recreation, commercial interests, and private development (Allen and Reuter 1996). Introduction of nonnative aquatic species, overharvesting (of native LCT), and other disturbances have caused irreversible changes to the nearshore fish assemblage (Heyvaert et al. 2013). Over the past 50 years a large increase in human population within the Tahoe Basin and a concomitant increase in shoreline development and alterations have occurred. For example, as a result of low water conditions, shorezone property owners have cleared their beaches of gravel, cobble, rock and boulders down to and beyond the water line to expose sandy beach. Removed substrate is usually piled along property lines, reducing the area of fish habitat when Lake Tahoe returns to “normal” levels. Construction of piling-supported piers and rock-crib piers have further altered nearshore habitat (Beauchamp et al. 1994a).

Based on concerns that increasing boating and presence of structures (i.e., piers) were affecting fish habitat, a multiphased fish study investigated the distribution of fish communities, as well as their interactions with littoral structures and habitat features, the results of which are generally described below (Byron et al. 1989; Beauchamp et al. 1991, 1994a; Allen and Reuter 1996).

Nearshore fish densities are highest during the summer and then decrease during fall as fish move to deeper parts of the lake. This occurs, in part, due to thermal stratification that restricts many fish to shallower depths (Byron et al. 1989). In addition to the permanent inhabitants of nearshore environments, YOY of most other fish also utilize the nearshore zone. In general, shallow (i.e., less than 30 feet deep) areas with large boulders or other complex environments support substantially more fish than simple (i.e., sandy substrate) littoral zone habitats (Byron et al. 1989). Yearling and older littoral fish generally do not use shallow, nearshore sandy substrate unless is it is less than 7 feet from complex rocky cover (Beauchamp et al. 1991). Rocky habitat is thought to provide important refuge from predation (Beauchamp et al. 1994a) and is considered good spawning habitat for many lake-dwelling species by TRPA. Allen and Reuter (1996) found nearly every gravel substrate location surveyed showed evidence of spawning. In contrast, higher densities of underyearling littoral fishes are associated with sandy substrates, likely because they take advantage of the warmest available temperatures located in shallow waters and their small size and transparency protect them from predators (Beauchamp et al. 1991). As underyearlings grow and gain more pigment they form schools to protect themselves from predation. Large aggregations of juveniles are prevalent along the marshy shore where they are able to take refuge in emergent aquatic vegetation (Moyle 2002).

The warm spring and summer months are the peak spawning period for many nearshore fish species in Lake Tahoe. The peak recreational boating period, which occurs from May 1 to September 30, corresponds with utilization of nearshore habitat by native fishes (Beauchamp et al. 1991) and warmwater game species. However, most native fish spawn during the night hours when shorezone activities decrease (Allen and Reuter 1996). Beauchamp et al. (1991) found that underyearlings, which generally use shallow areas did not occupy areas deep enough to be frequently disturbed by normal boat traffic. Nevertheless, boat traffic in marinas and around piers caused fish schools (i.e., yearlings and older fish) to retreat to cover, although they usually returned to normal activity patterns within 30 seconds (Beauchamp et al. 1991). Due to the short disturbance period, the study concluded that, even frequent encounters (e.g., 100 boat passages) would not impinge on foraging time enough to affect growth. To further investigate potential anthropogenic impacts on nearshore fishes, Allen and Reuter (1996) studied boating impacts on spawning. The researchers reported that boating occurring during maximum night spawning activities had no negative impact on spawning behavior. Further, artificial lighting associated with boating and other shorezone activities did not affect spawning behavior. Spawning became adversely affected only when shorezone disturbances reached an extreme level. A significant drop in egg survival occurred at one spawning site during Independence Day weekend at a location where boating activity was unusually high. Many boats parked along the nearshore and were subjected to wakes from boats coming and leaving the area, which caused beached boats to rock and bounce on eggs incubating in the nearshore substrate. It was recommended that this practice not be allowed for all boat types (including personal watercraft) (Allen and Reuter 1996).

Other human activities associated with shorezone recreation were also studied to determine how they may affect spawning fish during nighttime and daytime hours. Spawning fish were subjected to dogs swimming and people wading in the nearshore environment (Allen and Reuter 1996). Fish responded by swimming just far enough from the disturbance that they would not be physically harmed. Spawning aggregations showed a similar response by reestablishing themselves within 1 minute of disturbance (Allen and Reuter 1996).

The most common anthropogenic alteration to Lake Tahoe's nearshore is the construction of piling-supported piers (piers) and rock crib piers (cribs) (Beauchamp et al. 1994a). Piers in Lake Tahoe consist of 20- to 30-centimeter-diameter steel or wood pilings, spaced in approximately 16-foot intervals with mean dimensions of 75 feet long and 7 feet wide (Beauchamp et al. 1994a). Piers provide simple submerged structures that lack habitat complexity. Beauchamp et al. (1994a) studied piers and cribs to determine if these structures affected fish densities. The researchers reported that piers had no significant effect on littoral fish density, but that piers may positively affect fish abundance when the lake level is higher because some species may utilize the shaded areas under docks as cover. Allen and Reuter (1996) conducted another study to determine if piers and/or cribs affected fish spawning success. The researchers reported that substrate was more important than pier presence for littoral fish spawning success (Allen and Reuter 1996). The study concluded that areas of gravel replaced by pier piles should be mitigated to ensure no loss of spawning habitat.

Loss of habitat, from boat ramps and marinas was found to adversely affect spawning. During the spawning season, fish were observed in very shallow water (less than 10 inches deep) on boat ramps (Allen and Reuter 1996). The study authors concluded fish on the boat ramps were looking for suitable spawning substrate. Although no spawning was observed on ramps, at the same time fish were on the boat ramps the researchers observed spawning fish several feet away from the ramps (Allen and Reuter 1996). Sheet piles installed around rock cribs also eliminated spawning habitat. Although holes had been cut into the sheet piles to provide access to spawning habitat, the holes did not provide adequate access. This suggests structures that cover or remove spawning habitat have a negative impact on nearshore fishes (Allen and Reuter 1996).

TRPA Nearshore Fish Habitat Definitions

Findings from the studies discussed above have been used by TRPA to establish regulations for shorezone structures and the activities associated with them. TRPA, in coordination with CDFW, NDOW, and the Tahoe Environmental Research Center also considered these studies when defining prime fish habitat locations around the lake.

Prime Habitat maps were originally adopted in 1984 to classify the amount of habitat available to nearshore fish. Since then, the maps have been updated several times and were most recently updated in 2015. As newer mapping techniques and technology have become available, and the fish studies such as those described above have taken place, the maps have been refined to more accurately define available fish habitat. The most recent habitat inventory was conducted by O'Neil-Dunne et al. (2016). Based on the habitat inventory, TRPA's Geographic Information System database reported 37 acres of spawning habitat, 6,099 acres of feeding and/or cover habitat, and 7,706 acres of marginal habitat in Lake Tahoe, which equates to approximately 6,136 acres of prime habitat (sum of spawning and feeing/cover habitat) that is limited in distribution to distinct areas around the lake. Note that this analysis does not exclude mapped habitat that occurs above the highwater elevation, so the actual area of prime fish habitat is slightly less.

TRPA classifies nearshore habitat into three types based primarily on substrate size and characteristics, including (1) marginal habitats that correspond to nearshore areas dominated with sand and silt substrates, (2) feed and cover habitats that are areas dominated with cobble and boulder substrates, and (3) spawning habitats that are limited to areas of gravel (Byron et al. 1989; TRPA 1996). Naturally occurring cobble/boulder and gravel habitats (i.e., "spawning" and "feed and cover") are considered excellent or prime habitat and have been used to judge compliance with the adopted lake threshold standard, which is a no net loss standard (i.e., TRPA's goal is to prevent any loss of prime fish habitat). Exhibit 5-1 shows the distribution and quantity of marginal, feed and cover, and spawning habitats in Lake Tahoe.

Spawning Habitat

TRPA recognizes spawning habitat as an area that attracts, or can attract, fish for reasons of producing and fertilizing eggs. Spawning habitats are composed of relatively small diameter gravel substrates used by native minnows for spawning and rearing fry (TRPA 2016a). Shorezone substrate was classified as spawning habitat if most of the gravel within an area measured between 2 and 64 millimeters (mm) in diameter. Gravel beds used for spawning are dynamic (Osborne et al. 1985). Littoral currents and wave energy constantly move and redistribute spawning gravel and sands. Spawning areas occur in both sheltered and more open stretches of shoreline and may be enhanced by the presence of underwater springs (TRPA 2004:4-11). Furthermore, fluctuations of the lake level can affect the amount of gravels that are available for fish spawning (Ngai et al. 2010). Spawning habitats are randomly distributed along the shorezone, but all are located along the California shoreline (Exhibits 5-1 and 5-2).

Nearshore spawning habitat is used by several fish species during the warm spring and summer months (Exhibit 5-3). Generally, little information is readily available describing spawning habitat requirements or behavior for native fishes in Lake Tahoe. However, available information generally suggests that native fish species spawn in gravelly areas where eggs can develop relatively safely and remain oxygenated by wave action. The Tahoe Keys area supports highest densities of nonnative warmwater fish species in Lake Tahoe. The Tahoe Keys area generally would not be considered spawning habitat based on the TRPA definition which is defined by native fish spawning habitat requirements. Some populations of nonnative warmwater species utilize other areas of the lake, which may be considered spawning habitat based on the TRPA definition.

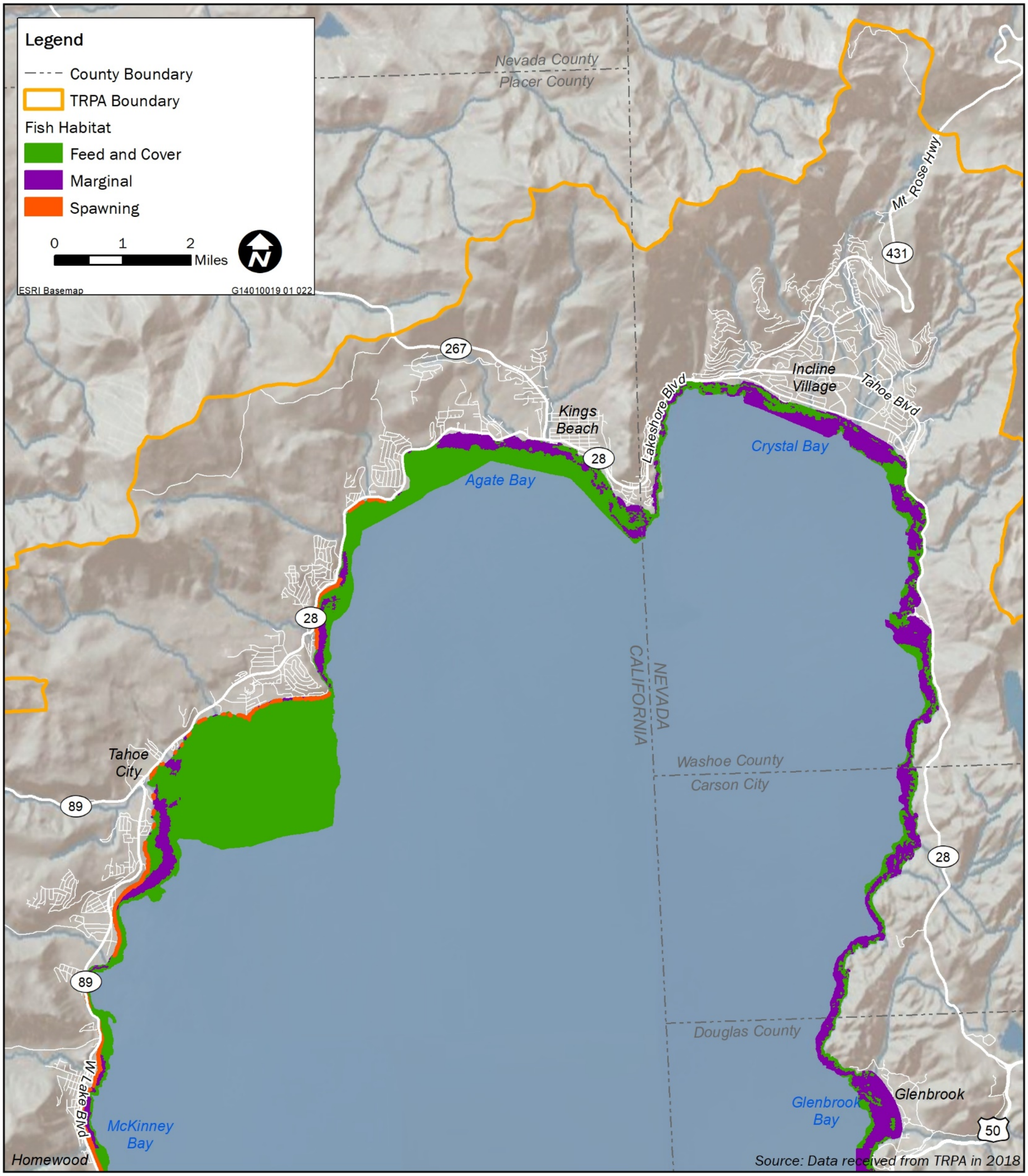
Feed and Cover

Larger rocky substrates (e.g., cobble, boulder) represent feed and cover habitats and are used by fish as foraging habitat and to provide refuge from predation (TRPA 2016a). Overhanging riparian vegetation is also important for providing shade to minimize rapid fluxes in stream and lake temperatures. In addition, some species of larval and postlarval fish often use shallow, sandy portions of the shorezone because high water temperatures provide for optimal growth (e.g., the South Shore Shelf, Lake Forest/Tahoe City Shelf).

As described in Section 5.3.2, preferred food items of fish vary between species. Food selection also varies within species, depending on the size of the fish and its stage of development. Young fish use calm water to find food and hide from predators. Suitable nursery habitats in Lake Tahoe are located in marshes and wetlands, in areas with sand substrate that supports vegetation, and in deep-water vegetation. Vegetation in these areas also provides excellent cover and provides favorable habitat for invertebrates needed for food by young fish. Feed and cover habitat occur everywhere except the south shore (Metz et al. 2006) (Exhibit 5-1).

Marginal

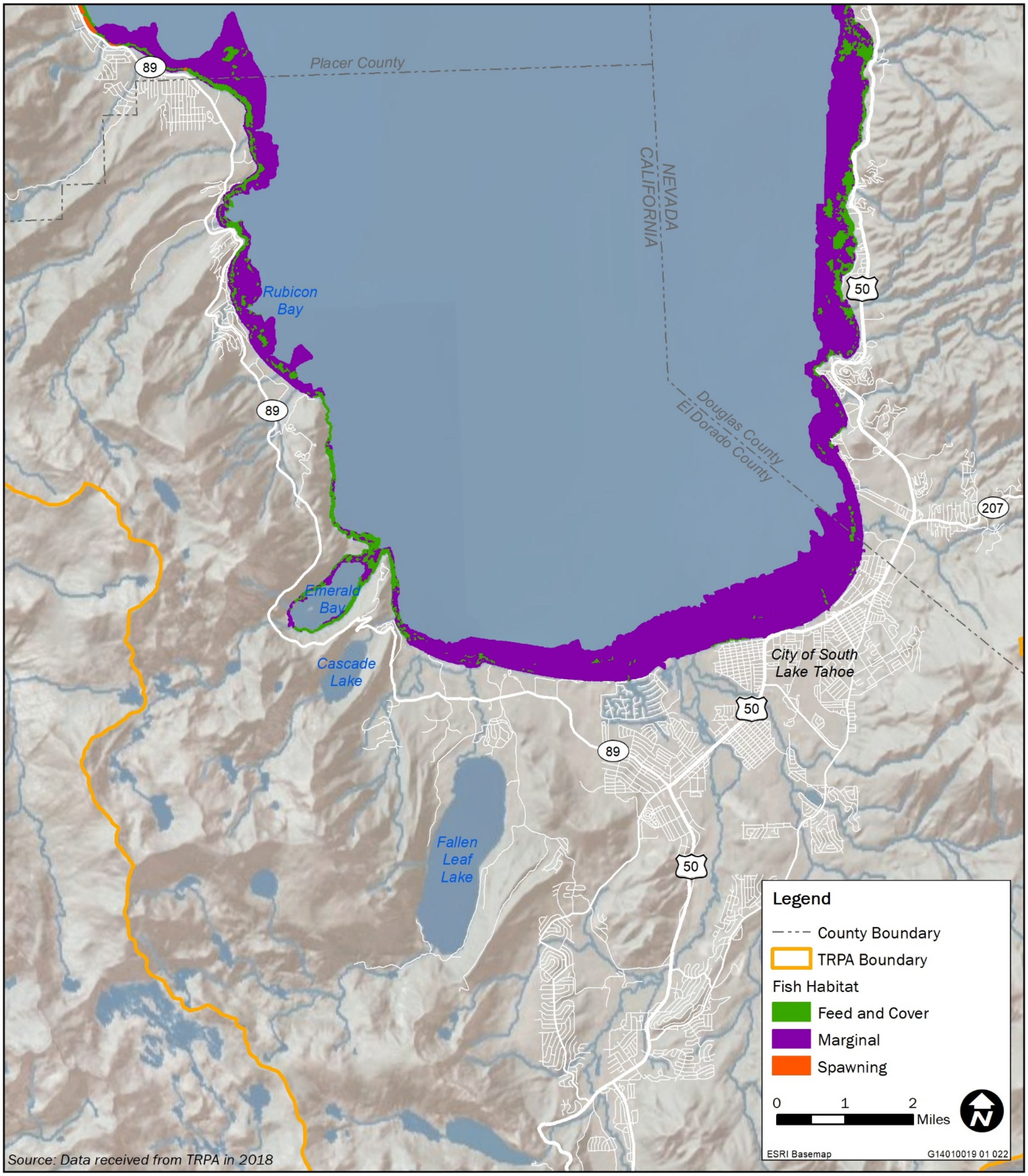
According to TRPA (2016a) marginal habitats are dominated by sand and silt substrates interspersed with occasional willow thickets that establish during low lake levels. When the TRPA Prime Fish Habitat maps were originally produced in 1984, shoreline areas that consisted of sand and silt substrates (less than 2 mm in diameter) were designated as marginal habitat. Although that terminology is still used today the term “marginal” habitat may be misleading because it implies that this habitat is of poor quality to fish. However, Beauchamp found that these substrates provided important nursery habitat for the underyearling littoral fish (Beauchamp et al. 1990, 1991). Furthermore, this type of habitat is used for spawning by tui chub. Marginal habitats are characterized by a predominance of sand and silt substrates that often are interspersed with vegetation, such as willow. Marginal habitat locations are depicted in Exhibit 5-1.



TAHOE REGIONAL PLANNING AGENCY

Exhibit 5-1 **Distribution and of Habitat Types in Lake Tahoe (North)**

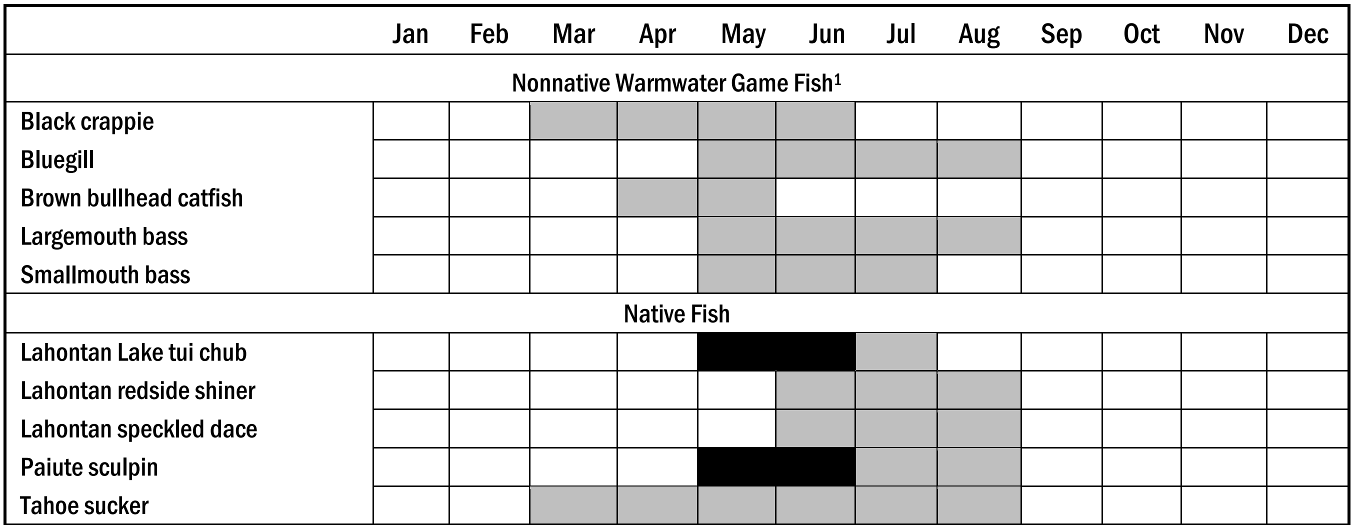
SHORELINE PLAN
Enhancing Recreation & Protecting Lake Tahoe's 72 Miles of Shoreline



TAHOE REGIONAL PLANNING AGENCY

Exhibit 5-2 Distribution and of Habitat Types in Lake Tahoe (South)

SHORELINEPLAN
Enhancing Recreation & Protecting Lake Tahoe's 72 Miles of Shoreline



[1]. Spawning for many warmwater game fish species is initiated when water temperatures are appropriate. Therefore, these spawning periods should be considered generalized spawning periods for evaluation purposes in this EIS. Because water temperatures in Lake Tahoe could change over time as a result of climate change and other factors these generalized spawning periods also could change.
For references and details see species descriptions in the text.

Period of peak spawning
Period of spawning

Exhibit 5-3 Spawning Periods for Native and Nonnative Fish That Spawn in the Nearshore Zone of Lake Tahoe

TRIBUTARY STREAMS

Sixty-three tributary streams are known to provide suitable habitat necessary for Lake Tahoe coldwater game fish reproduction (with the exception of lake trout). Some nongame species also use tributaries for spawning, but the proportion of the native fish species using the tributaries for spawning is unknown. The Shoreline Plan will not affect tributary streams and thus, these areas are not discussed further.

Although the Shoreline Plan will not construct structures in tributary streams, shorezone structures generally can have impacts on stream mouths. Therefore, TRPA has implemented stream mouth protection zones to ensure new structures do not impede access to spawning habitat in lotic environments.

Marshes and wet meadows once commonly occurred where streams entered Lake Tahoe but, due to residential and commercial development, are now largely restricted to the South Shore (notably Taylor Creek and the Upper Truckee Marsh). Stream outlets serving as entrances to spawning stream habitats are found at numerous locations around Lake Tahoe, although most lie along the California shoreline. In addition, these stream mouths are known to possess foraging habitat used by several game and nongame fishes. Prohibiting construction of shorezone structures (such as piers) within the zone of a stream mouth is necessary because debris can become entangled with shorezone structures and create barriers to fish migratory movements during storm events. Additionally, stream mouths naturally meander, moving laterally along the shoreline, and over time may align itself directly in line with a shorezone structure. Building structures within the influence of the natural meander pattern of a stream mouth also interferes with the streams ability to meander naturally. Currently, TRPA recognizes 24 stream mouths from which shore development is prohibited within 200 feet on either side of the stream.

PELAGIC HABITAT

The pelagic zone of the lake provides important habitat to numerous fish species. In the summer months, when the lake is more heavily used for recreation, many of the pelagic fish species utilize the hypolimnion (i.e., deeper portions of the lake) where temperatures remain cool. Because the Shoreline Plan elements will be implemented along the 72-mile-long shorezone of Lake Tahoe, little if any impact on the pelagic environment will occur as a result of placing structures in the nearshore areas of the lake. Furthermore, TRPA does not have any pelagic standard for fish protection.

5.4 ENVIRONMENTAL CONSEQUENCES AND MITIGATION MEASURES

5.4.1 Significance Criteria

Significance criteria relevant to aquatic biological resources are summarized below. The applicable TRPA threshold standards, the aquatic biological resource criteria from the TRPA Initial Environmental Checklist, and other relevant information were considered in the development of the significance criteria. An impact would be considered significant if it would:

- result in a net decrease in the amount of TRPA-designated prime fish habitat;
- result in harmful ecological economic, social, or public health impacts from the introduction or spread of invasive species;
- substantially change the diversity or distribution of aquatic species;
- substantially reduce the number or reduce the viability of special-status fish species;
- result in a barrier to fish movement that would block access to spawning habitat; or
- substantially reduce the suitability of habitat for native or game fish species.

5.4.2 Methods and Assumptions

The assessment of impacts on fish and aquatic biological resources consists of three primary elements: (1) temporary and localized impacts associated with construction, (2) permanent impacts on habitat associated with structures, and (3) impacts associated with increased recreational activities.

The evaluation of fisheries and aquatic biological resource impacts were based on a review of documents pertaining to the Tahoe Basin shorezone, including scientific studies and TRPA regulations and planning documents. The information obtained from these sources was reviewed and summarized to establish existing conditions and to identify potential environmental effects, based on the standards of significance presented in this section.

The analysis of impacts assumes that all proposed shorezone structures for Alternatives 1, 3, and 4 would be placed in prime fish habitat; however, the relative size of structures in marginal and all fish habitat types has also been provided for reference. In addition, it was assumed that all proposed shorezone structures under Alternative 2 would be constructed in marginal fish habitat due to the prohibition on placing structures in prime fish habitat associated with that alternative. The analysis further considers that all piers under all four alternatives would be constructed to the largest multiple-use design standards.

To calculate substrate displacement for prime fish habitat, it was assumed that piers would each have 20 pilings, with each piling displacing 0.8 square feet (sq. ft.) of prime fish habitat lakebed substrate. This yields a disturbance footprint of approximately 15 sq. ft. of prime fish habitat that would be displaced for each pier. Buoy and slip anchors were assumed to disturb approximately 4 sq. ft. of prime fish habitat. Boat ramps were assumed to be 10 feet wide and 75 feet long, each therefore resulting in a disturbance footprint of approximately 750 sq. ft. For impacts associated with construction disturbance of substrate (which would generally be larger than the permanent footprint of these structures), it was assumed that the affected area would be:

- for piers, one and a half times the footprint of pier pilings;
- for buoys, equal to the bottom footprint of anchors; and
- for boat ramps, twice the size of the boat ramp footprint.

Impact 5-1: Increased risk of AIS introduction or spread

The increase in boat launches under Alternatives 1, 2, and 3 could increase the risk of AIS introductions, but this risk would not be substantial because the rigorous and effective prevention programs (including boat inspection, decontamination, outreach, and education) would continue. However, the increases in recreational boating under Alternatives 1, 2, and 3 would increase the risk that invasive macrophytes and Asian clams already in Lake Tahoe would be spread within the lake, creating new populations and increasing the abundance and distribution of AIS. This would be a **significant** impact for Alternatives 1, 2, and 3. Implementation of the required mitigation measures would reduce the risk of AIS spread by requiring AIS management at marinas, promoting technologies that reduce the risk of AIS transport, and, for Alternative 2, increasing the control of existing AIS infestations. These mitigation measures would reduce the impact to a **less-than-significant** level for Alternatives 1, 2, and 3.

Alternative 4 would result in no increase in boating activity and would not increase the risk of AIS introduction and spread. Alternative 4 would also require that all marinas develop and implement an AIS management plan. This would reduce the risk of AIS introductions at, or spread from, marinas. Therefore, Alternative 4 would have a **beneficial** effect related to AIS introductions and spread.

Each alternative would result in the construction and placement of new structures in Lake Tahoe, which would allow for increased recreation levels associated with boating and angling. Recreational activities involving watercraft (motor boats, personal watercraft, kayaks, canoes and float tubes) and/or fishing are the most likely vectors for new AIS introductions into Lake Tahoe (USACE 2009). The alternatives could affect the introduction and spread of aquatic invasive plants and aquatic invasive macroinvertebrates.

Aquatic Invasive Plants

There are two known species of nonindigenous aquatic plants in Lake Tahoe: Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*). These species adversely affect recreational activities, navigation, and ecosystem dynamics. In addition, coontail (*Ceratophyllum demersum*), a native species, is also considered a nuisance in some areas of the lake due to excessive growth. Because most Eurasian milfoil populations are within marinas or other protected nearshore areas, dispersible fragments can easily be created by boat propellers or from mechanical harvesting (Wittmann et al. 2015). Although increased boating may increase the risk of invasive macrophytes spreading, a study by Wittmann et al. (2015) reported that no correlation between the presence of Eurasian watermilfoil and recreational boater visitation was identified. Thus, while recreational boats may be a dispersal vector, Eurasian watermilfoil distribution may be more dependent on advective transport such as wind-driven surface currents, transport by birds, habitat limitations, or variations in temporal scales (Wittmann et al. 2015). Although the study by Wittmann et al. (2015) was focused on Eurasian watermilfoil, data from their work suggests the abrupt appearance of curly-leaf pondweed in Emerald Bay may have occurred as a result of recreational boating. Thus, while there is some uncertainty with respect to the role recreational boating has on the spread of aquatic invasive plants, it is possible that increases in recreational boating could increase the spread of aquatic invasive plants.

Efforts are currently underway to control invasive aquatic plants in Lake Tahoe and other lakes in the Region. In 2015 a plan was finalized, and feasible control strategies for specific invasive species in specific locations began to be implemented. Nonetheless, invasive plants continue to spread throughout the lake and continue to adversely affect native fishes.

Aquatic Invasive Macroinvetebrates

Since the 1960s *Mysis*, signal crayfish, and Asian clams have been introduced and have spread in Lake Tahoe. Introduction of these nonnative species has corresponded with a significant decrease in native benthic invertebrates, with substantial declines in density of most taxa (Caires et al. 2013). Because crayfish have already been introduced and are well-established in the lake, increased recreational activities are not expected to increase their population size or location within the lake.

Asian clams are the first and, to date, only molluscan AIS in Lake Tahoe. Asian clams are the only AIS macroinvertebrate, currently present, that could possibly be spread around Lake Tahoe due to human activities. Asian clams are small (less than 1.5 inches) and can spread rapidly. A single clam can reproduce alone and release hundreds of juveniles a day. Asian clams can be found in any substrate, but prefer fine clean sand, clay, coarse sand, or gravels in shallow warm water (USACE 2009). fishes. Asian clams can spread by pediveliger (i.e., a stage in its life cycle where it is able to crawl using its foot) dispersal, generation of viscous-mucous threads, anthropogenic and animal transport, and passive hydraulic transport (Wittman et al. 2013). Because Asian clams can be spread passively by wave action they could also spread by passive movement in the waves created by boat wakes. However, this potential dispersion method has not been identified in review of available literature. Nonetheless, the continuation of no-wake zones under all the alternatives would reduce potential for the species to spread as a result of boat wake generation. Asian clams can also be transported via boat ballast water or the juvenile byssal attachment to boat hulls (Kramer-Wilt 2008; Sousa et al. 2008). The 2017 State of the Lake Report discusses the implications of boat use on the spread of Asian clams (TERC 2017:6.17) and speculates that transport via boat ballast water may have led to the establishment of new populations of Asian clams in Lake Tahoe.

Other AIS species, such as quagga and zebra mussels, New Zealand mudsnails, and hydrilla, are not yet present in the lake but are present in other water bodies in California and Nevada (USACE 2009). Suitable habitat for species is potentially present in Lake Tahoe, and increased recreational activity has the potential to increase the risk of introductions.

AIS Inspection Program

Under the TRPA AIS inspection program, every motorized boat accessing Lake Tahoe is inspected per TRPA Code 63.4.2. From 2015 through 2107, an average of 15,377 boats were inspected annually (Zabaglo, pers. comm., 2018). Boats are decontaminated with 140 degrees Fahrenheit (°F) water if AIS are encountered through visual and tactile inspections, if there is water present in any section of the boat, or if the boat had previously been in a lake with known AIS. Out of the 15,377 annual inspections, an average of 3,735 are decontaminated annually. On average, 38 vessels are positively identified as carrying AIS each year (Zabaglo, pers. comm., 2018). This is the equivalent to a positive AIS identification on approximately 1 out of every 400 boats entering Lake Tahoe. Boat ramp and marina inspectors have never caught a boater trying to enter the lake while intentionally trying to avoid an AIS inspection.

The AIS program is funded through the collection of watercraft inspection and decontamination fees and through grant funding from the States of Nevada and California. The collected fees cover approximately half of the program cost and the other half is funded by state funds. The AIS program costs are largely due to static operational costs such as inspector salaries, decontamination equipment, and administration. Therefore, the program costs do not increase in proportion to the number of inspections (Zabaglo, pers. comm., 2018). The cost of supplies (stickers, seals, hot water) is covered by the collected inspection and decontamination fees; therefore, an increase in inspections would generate additional fees and would cover the additional supply costs. Based on the projected increases in boat launches under each alternative, no additional funding would have to be obtained to maintain the AIS inspection program at existing levels (Zabaglo, pers. comm., 2018).

Alternative 1: Proposed Shoreline Plan

Under Alternative 1, up to 2,116 new moorings and two new boat ramps could be constructed. These structures would result in an estimated 7,300 additional annual boat launches and approximately 38,200 additional boat trips, which would increase the potential for the introduction and spread of AIS. Alternative 1 includes the second highest number of boat launches and boat trips of all the alternatives considered.

Therefore, the likelihood of introduction and spread of nonnative aquatic weeds under Alternative 1 is greater than Alternatives 3 and 4, but less than Alternative 2. AIS inspection and decontamination requirements currently in place would continue under Alternative 1, including compliance with TRPA Code 63.4.1 C, which states that "the launching, or attempting to launch, of any motorized watercraft into the waters of the Lake Tahoe region without an inspection by TRPA or its designee, to detect the presence, and prevent the introduction of, aquatic invasive species" is prohibited. Additionally, nonmotorized watercraft and seaplanes are subject to inspection and are included in this provision, if determined necessary by TRPA or its designee. Further, TRPA Code 63.4.2 B states that "all watercraft and seaplanes subject to inspection and/or decontamination pursuant to subparagraphs 63.4.1.C and 63.4.2.B shall be permitted to enter the waters of the Lake Tahoe region only if: (a) the inspection and/or decontamination is performed and completed by an individual trained and certified pursuant to TRPA standards and requirements for aquatic invasive species inspection and decontamination, and (b) following inspection and/or decontamination, the launch or landing, as appropriate, is authorized by an inspector trained and certified pursuant to TRPA's standards and requirements for aquatic invasive species inspections."

Although the increased number of boat launches under Alternative 1 could increase the risk of AIS introduction, the additional risk would not be substantial because Lake Tahoe has one of the nation's most rigorous AIS prevention and recreational boat inspection programs, which would continue under Alternative 1. As described above, this program includes a mandatory boat inspection program and mandatory decontamination for all high-risk boats. This program has functioned effectively since its inception and no new species of AIS have been introduced. The inspection program would continue to function under the existing funding system, which would be adequate to accommodate the expected increase in inspections (Zabaglo, pers. comm., 2018). In addition, TRPA and partner organizations would continue to implement AIS prevention efforts that include outreach, education, and voluntary action by the boating public, and would expand these efforts through new education programs at inspection stations and marinas, as described in Chapter 2, "Description of Proposed Project and Alternatives,"

While introduction of AIS from additional boat launches would not be expected because of the highly effective existing program, it is possible that increases in recreational boating could increase the spread of Eurasian watermilfoil, curly-leaf pondweed, and coontail (a native nuisance species), which are already found in Lake Tahoe. Increases in recreational boating could also increase the spread Asian clams, via ballast water. The risk of AIS spread would be offset by ongoing and expanded control efforts guided by the Lake Tahoe AIS Management Plan for CA and NV (TRPA 2014). As control efforts reduce the extent of existing populations, the risk that these populations will be spread by recreational boating decreases. Between 2009 and 2015, approximately 40 acres of lakebed were treated for AIS, or an average of 6.7 acres per year. As described in Chapter 2, "Description of Proposed Project and Alternatives," Alternative 1 would develop a new fee program that would fund additional AIS control projects. The fee would be assessed on recreational boaters and would be sufficient to fund an additional 3 acres of invasive macrophyte or Asian clam control each year, which would represent an increase of approximately 45 percent in the areal extent of lakebed treated annually for AIS control. As described in Chapter 2, Alternative 1 would result in an estimated 16 percent increase in the annual number of boat trips. While the additional boat trips would increase the risk of AIS spread, the additional AIS control would decrease this risk.

Alternative 1 would require that marinas seeking reconfiguration or expansion develop and implement AIS management plans. Because marinas include areas where invasive macrophytes are most dense and where recreational boating tends to be concentrated, such AIS management plans would be highly effective at reducing the risk that invasive macrophytes would be spread by recreational boating. However, marinas that do not expand or reconfigure would not be required to prepare and implement AIS management plans. Because marinas contain fueling facilities, the increase in boat trips under Alternative 1 would increase boat traffic in marinas as the additional boats visit marinas to refuel or use other marina amenities. This increase in boat traffic at marinas would occur at all marinas regardless of whether the marina added additional mooring or launching capacity. Thus, the approximately 16-percent increase in recreational boating would increase the potential for AIS spread at marinas, and this risk would not be fully offset by existing and proposed control programs.

The increase in boat launches under Alternative 1 could increase the risk of AIS introductions, but this risk would not be substantial because the rigorous and effective prevention programs would continue and new educational programs would be implemented. The new fee and expanded AIS control would offset the increased risk that invasive macrophytes and Asian clams would be spread within the lake itself. However, the increased boat traffic at marinas, where AIS can be most dense, would increase the risk that boats would spread AIS, creating new populations and increasing AIS abundance and distribution. This would be a **significant** impact.

Alternative 2: Maintain Existing TRPA Shorezone Regulations (No Project)

Under Alternative 2, an estimated 4,871 new buoys, 1,897 new slips (including slips within two new marinas), six new public boat ramps, and 168 new private boat lifts could be constructed. These structures would result in an estimated 22,600 additional annual boat launches and approximately 124,800 additional annual boat trips, which would increase the potential for the introduction and spread of AIS. This would result in an estimated 53-percent increase in the number of annual boat trips; more than any other alternative. As with Alternative 1, existing AIS inspection and decontamination requirements would remain in place.

Although the increased number of boat launches under Alternative 2 could increase the risk of AIS introduction, the additional risk of AIS introduction would not be substantial because of the rigorous AIS prevention and recreational boat inspection program, described above, which would continue under Alternative 2. The inspection program would continue to function under the existing funding system, which would be adequate to accommodate the expected increase in inspections under Alternative 2 (Zabaglo, pers. comm., 2018).

As described above, increases in recreational boating could increase the spread of Eurasian watermilfoil, curly-leaf pondweed, and coontail (a native nuisance species), and Asian clams already in Lake Tahoe. Under Alternative 2, existing AIS control programs would remain, but they would not be expanded by a new AIS control funding source. Because Alternative 2 would result in an increase in boat trips but no increase in AIS control, it would increase the risk of AIS spread.

Alternative 2 would not require marina AIS management plans and would therefore not reduce the risk that invasive macrophytes would be spread from marinas by recreational boating. Thus, the approximately 53-percent increase in recreational boating would increase the potential for AIS spread, and this risk would not be fully offset by existing control programs. The approximately 53-percent increase in boat trips would substantially increase the risk the invasive macrophytes and Asian clams would be spread within the lake, creating new populations and increasing the abundance and distribution of AIS. This would be a **significant** impact.

Alternative 3: Limit New Development

Under Alternative 3, up to 365 new public buoys and one new public boat ramp could be constructed. These structures would result in an estimated 3,000 additional annual boat launches and approximately 8,600 additional annual boat trips, which would increase the potential for the introduction and spread of AIS. This would result in an estimated 4-percent increase in the number of annual boat trips; fewer than Alternatives 1 and 2, but more than Alternative 4. As with Alternative 1, existing AIS inspection and decontamination requirements would remain in place.

Although the increased number of boat launches under Alternative 3 could increase the risk of AIS introduction, the additional risk of AIS introduction would not be substantial for the same reasons described above for Alternatives 1 and 2.

Increases in recreational boating could increase the spread of Eurasian watermilfoil, curly-leaf pondweed, and coontail, and Asian clams. However, Alternative 3 would include the same new AIS control funding source and increased AIS control as Alternative 1. For the reasons described above, the expanded control efforts would offset the increased risk of AIS spread.

As with Alternative 1, Alternative 3 would require marina AIS management plans, but only for marinas that expand or reconfigure. The approximately 4-percent increase in recreational boating would increase boat traffic at all marinas. It is possible that the additional 8.600 annual boat trips would result in a very limited increased risk of AIS spread from marinas. However, it would result in some increased potential for AIS spread at marinas.

The increase in boat launches under Alternative 3 could increase the risk of AIS introductions, but this risk would not be substantial due to the continuation of rigorous and effective prevention programs. The approximately 4-percent increase in boat trips would be offset by increases AIS control. However increased boat traffic at marinas, where invasive macrophytes tend to be most dense, could increase the risk the invasive macrophytes would be spread from marinas to the lake, creating new populations and increasing the abundance and distribution of AIS. This would be a **significant** impact.

Alternative 4: Expand Public Access and Reduce Existing Development

Alternative 4 would not allow for new structures that could increase boating capacity. It would result in no increase in the number of boat launches and no increase in the number of boat trips. Therefore, Alternative 4 would not increase the risk of AIS introduction and spread. Alternative 4 would also require that all marinas develop and implement an AIS management plan. This would reduce the risk of AIS introductions at, or spread from, marinas. Therefore, Alternative 4 would have a **beneficial** effect related to AIS introductions and spread.

Mitigation Measures

Mitigation Measure 5-1a: Require marina aquatic invasive species management plans

This mitigation measure would be required for Alternatives 1, 2, and 3.

TRPA will require that all marinas prepare and implement an AIS management plan within 3 years of adoption of the Shoreline Plan. The AIS management plans shall, at a minimum, (1) identify strategies to prevent the establishment of invasive macrophytes and Asian clams within the marina (e.g., improved water circulation), (2) include an AIS monitoring, early detection, and response program within the marina, which could be in partnership with resource management agencies and/or organizations, and (3) include a public education component. For marinas that already contain AIS, the AIS management plan shall identify measures to control or eradicate existing AIS and reduce the potential for spread.

Mitigation Measure 5-1b: Promote the development of AIS-resistant boats

This mitigation measure would be required for Alternatives 1, 2, and 3.

TRPA will continue to regularly communicate with representatives of the watercraft industry, including trade associations and manufactures of watercraft or watercraft components, to promote the development and widespread commercial utilization of technologies that lower the potential for the spread of AIS. Innovations such as ballast tank filters, heated ballast water intakes in engines, and better draining ballast tanks are currently being developed by various manufacturers, but they are not yet commercially available on a widespread basis. Although many of these innovations are not yet commercially viable, they may be by the full buildout of the Shoreline Plan Alternatives. TRPA will regularly coordinate with representatives of the watercraft industry to advocate for and demonstrate a commercial interest in the continued development and adoption of such technologies. TRPA will enact policies to encourage or require the use of such technologies when they become feasible.

Mitigation 5-1c: Establish a mitigation fee program to increase AIS control.

This mitigation measure would be required for Alternative 2.

TRPA will establish an AIS mitigation fee program that will fund increased levels of AIS control. The fee will be used to implement projects that reduce the abundance and distribution of Asian clam, Eurasian watermilfoil, curly-leaf pondweed, coontail and/or other AIS that may be introduced in the future and can be spread by recreational boating. The fee will be assessed on recreational boaters either during AIS inspections or at launch points. The fee per launch or boat will be the same as that proposed under Alternative 1, which will be sufficient to increase existing control efforts commensurate with the projected increase in annual boat trips under Alternative 2.

Significance after Mitigation

With implementation of Mitigation Measure 5-1a each marina would implement measures to reduce the risk of new infestations and control or eradicate existing infestations. This would reduce the risk of AIS spread because marinas can contain the densest infestations of invasive macrophytes and can serve as a vector source when recreation boats launch or visit marinas. Mitigation Measure 5-1b would encourage the eventual widespread adoption of ballast tank filters, heated ballast water intakes in engines, better draining ballast tanks, and/or other technologies that reduce the potential for recreational boats to spread Asian clams or other AIS. Mitigation Measure 5-1c would institute a fee that fund increased AIS control efforts under Alternative 2. The increase in AIS control efforts would be proportional to the increase in boating activity anticipated under Alternative 2, which would reduce the extent of AIS infestations and thereby reduce the risk that recreational boats would spread AIS. Taken together, these mitigation measures would substantially reduce the potential for the increase in recreational boating to increase the spread of AIS lake-wide under Alternative 2, and from marinas under Alternatives 1, 2, and 3. This impact would be reduced to a **less-than-significant** level for Alternatives 1, 2, and 3.

Impact 5-2: Loss of prime fish habitat

The implementation of the Shoreline Plan has the potential to result in a net reduction in the amount of prime fish habitat, as defined by TRPA, due to placement of shorezone structures within this habitat. Alternatives 1 and 3 would require habitat replacement at a 1.5:1 ratio, resulting in no net loss in prime fish habitat, which would be a **less-than-significant** impact. Alternative 2 would prohibit construction of structures within prime fish habitat and would therefore have **no impact**. Alternative 4 would require habitat replacement at a ratio of 2:1, which would not cause a decrease in the amount of prime fish habitat, and therefore would result in a **less-than-significant** impact.

In Lake Tahoe, parts of the nearshore are utilized by both nonnative and native fish species as feed and cover habitat, as well as seasonally for spawning and rearing young (Beauchamp et al. 1994a:385). As described above, TRPA classifies nearshore fish habitat into marginal, feed and cover, and spawning habitat types (TRPA 2016a:7-24):

TRPA considers cobble/boulder and gravel substrates as “excellent” or “prime” fish habitat, and it is acreage measurements of these substrates that have been used to judge compliance with the adopted lake habitat threshold standard. The threshold for fisheries requires nondegradation of fish habitat and maintenance of 5,948 acres of “excellent” fish habitat in Lake Tahoe. O’Neil-Dunne et al. (2016:19) determined that the threshold was in attainment with approximately 6,136 acres of “prime” fish habitat in Lake Tahoe’s nearshore/littoral zone. Any loss of prime fish habitat would conflict with the nondegradation threshold standard and constitute a potentially significant effect.

The placement of piers and buoys in spawning or feed/cover habitat has limited impact on native fish populations and the impacts can be mitigated (Beauchamp 1994a:6). Spawning habitat (gravel) in the nearshore is naturally limited because of upland geology, and where suitable habitat exists, spawning has been observed in the immediate vicinity of piers and buoys (Allen and Reuter 1996). Empirical observations suggest that boating activity associated with piers and buoys does not appear to adversely affect spawning activity or egg viability (Beauchamp 1994a:6). With this information in mind, TRPA has developed Alternatives 1, 3, and 4 to allow new structures to be placed within prime fish habitat. To comply with the nondegradation threshold, Alternatives 1, 3, and 4 would require replacement of any prime fish habitat with the same type of substrate elsewhere in the lake. Table 5-2 shows the amount of fish habitat affected by each alternative.

Table 5-2 Fish Habitat Affected by Placement of Shorezone Structures for All Alternatives

	Footprint in Substrate (sq. ft.)	Prime Fish Habitat Replacement (sq. ft.)	Prime Fish Habitat Affected by Structures (%)	Marginal Fish Habitat Affected by Structures (%)	All Fish Habitat Types Affected by Structures (%)
Alternative 1					
Piers (138)	2,084	3,126	0.001	0.0009	0.0005
Buoys (2,116)	8,422	12,633	0.005	0.004	0.002
Boat ramps (2)	1,500	2,251	0.0008	0.0007	0.0004
Total disturbance	**12,006**	**18,009**	**0.004**	**0.004**	**0.002**
Alternative 2					
Piers (476 multiple-use)	7,173	10,760	n/a	0.003	0.002
Buoys (4871)	19,484	29,226	n/a	0.0087	0.0048
Boat ramps (4)	4,500	6,750	n/a	0.0020	0.0011
Total disturbance	**31,157**	**46,736**	**n/a**	**0.009**	**0.005**
Alternative 3					
Piers (91)	1,371	2,057	0.0008	0.0006	0.0003
Buoys (365)	1,454	2,181	0.0008	0.0006	0.0004
Boat ramps (1)	750	1,125	0.0004	0.0003	0.0002
Total disturbance	**3,575**	**5,363**	**0.001**	**0.001**	**0.001**
Alternative 4					
Piers (15 public)	226	452	0.0002	0.0001	0.0001

Alternative 1: Proposed Shoreline Plan

The Shoreline Plan would allow new shorezone structures and repairs and modifications to existing structures. These projects would require prime fish habitat replacement at a 1.5:1 ratio. Using the assumptions described above, the Shoreline Plan would result in the loss of a total of 0.28 acre of prime fish habitat from the construction of 138 piers (2,084 sq. ft. of prime fish habitat loss), 2,116 buoys/slips (8,422 sq. ft. of prime fish habitat loss), and 2 boat ramps (1,500 sq. ft. of prime fish habitat loss). With a 1.5:1 replacement ratio, this would result in the creation of 18,009 sq. ft. or 0.41 acre of prime fish habitat, ensuring no net decrease. The effects of habitat disturbance and restoration and habitat replacement activities on fisheries are addressed in Impact 5-4, Permanent Habitat Modification, below. Because Alternative 1 would result in no net decrease in the extent of TRPA-designated prime fish habitat, this impact would be **less than significant.**

Alternative 2: Maintain Existing TRPA Shorezone Regulations (No Project)

TRPA Code Section 84.4 (adopted in 1987) prohibits the placement of new structures in prime fish habitat. This would be maintained with the implementation of Alternative 2; therefore, this alternative would result in **no impact** as there would be no change to prime fish habitat.

Alternative 3: Limit New Development

Alternative 3 would allow new shorezone structures and repairs and modifications to existing structures that would rely on habitat replacement at a 1.5:1 ratio. Using the assumptions described above, Alternative 3 would result in the loss of a total of 0.08 acre of prime fish habitat from the construction of 91 piers (1,371 sq. ft. of prime fish habitat loss), 365 buoys/slips (1,454 sq. ft. of prime fish habitat loss), and one boat ramp (750 sq. ft. of prime fish habitat loss). With a 1.5:1 replacement ratio, this would result in the creation of 5,363 sq. ft. or 0.12 acre of prime fish habitat, resulting in no net decrease. Because Alternative 3 would result in no net decrease in the extent of TRPA-designated prime fish habitat, this impact would be **less than significant.**

Alternative 4: Expand Public Access and Reduce Existing Development

Alternative 4 would authorize 15 new public piers and allow repairs and modifications to existing structures. These projects would rely on prime fish habitat replacement at a 2:1 ratio. Using the assumptions described above, Alternative 4 would result in the loss of 226 sq. ft. of prime fish habitat from the placement of 15 piers, which would be replaced at a 2:1 ratio, creating 452, or 0.01 acre of new prime fish habitat. Because Alternative 4 would result in no net decrease in the extent of TRPA-designated prime fish habitat, this impact would be **less than significant.**

Mitigation Measures

No mitigation is required.

Impact 5-3: Construction-related impacts

Construction of new shorezone structures and dredging under all four Shoreline Plan alternatives could affect all species considered, except lake trout because they do not utilize nearshore habitats. Effects on species that could use nearshore habitats would be greatest on native minnow species that spawn in nearshore areas, including Lahontan Lake tui chub. Effects on special-status salmonids, including LCT and mountain whitefish, as well as other coldwater game fish species, would generally be limited to adults migrating to spawning tributaries and juveniles using nearshore areas for rearing.

All of the alternatives would produce a small amount of temporary disturbance relative to both prime fish habitat and marginal fish habitat. Additionally, based on the life history characteristics and habitat use for the species evaluated, construction-related effects would not be adverse for any fish species under any of the alternatives. Therefore, implementation of any of the alternatives would be **less than significant.**

Suspended Sediment and Turbidity

Construction activity permitted under the Shoreline Plan alternatives could adversely affect water quality in the shorezone by accelerating soil erosion and sedimentation, increasing turbidity, and releasing pollutants. A detailed discussion of water quality impacts from construction and dredging, and regulatory programs pertaining to water quality protection, is presented in Impact 6-1 in Chapter 6, "Hydrology and Water Quality."

Increased suspended sediments and turbidity potentially could affect nearshore fish and their habitat by reducing egg and larva survival, interfering with feeding activities, causing breakdown of social organization, clogging the gills and digestive tract, and by reducing primary and secondary productivity. The magnitude of potential impacts on fish would be dependent upon the fish species, timing and extent of increased suspended sediment, turbidity and sedimentation, and environmental conditions (e.g., wind, waves) in the lake during and immediately following construction (Reardon et al. 2016). Pulses of increased suspended sediment can displace fish as they seek clearer water causing physical and behavioral changes that may induce physiological stress, reduce feeding efficiency (Madej et al. 2004), increase susceptibility to predators and reduce respiratory efficiency (Waters 1995). Deposition of finer sediments such as, clay, silt and sand can also bury macroinvertebrates and other food sources.

At higher turbidities, rainbow trout have been shown to shift from stationary feeding to actively searching for prey (Sweka and Hartman 2001b, cited in Hazelton and Grossman 2009). Similarly, creek chub and brook trout have been shown to be more active in turbid conditions compared to fish in clear water (Grandall and Swenson 1982, cited in Hazelton and Grossman 2009). This may translate into a greater energetic cost per prey item captured. Increases in turbidity significantly reduce foraging success of rosyside dace, possibly due to the increased energy expended to capture each prey item (Hazelton and Grossman 2009). In contrast, Lahontan redsides were found to be slightly better at capturing prey in turbid conditions (Vinyard and Yuan 1996). Turbidity has been correlated to decreased juvenile salmonid growth rates due to decreased foraging success, decreased prey availability and disturbance of normal social behavior (Bash et al. 2001).

Because increases in suspended sediment and turbidity can cause negative physiological impacts on fish, most fish avoid areas of increased suspended sediment and turbidity. Juvenile salmonids may alter their migratory behavior by moving laterally or downstream to avoid turbid areas (Sigler et al. 1984). Larger fish tend to be more tolerant of high concentrations of suspended sediment than smaller fish, although migrating adult salmonids may avoid areas with high silt loads (Bjorn and Reiser 1991).

Because of the sensitivity of fish to turbid conditions, fish in an area of construction would be expected to swim to an unaffected portion of the lake in response to elevated suspended sediment and turbidity. Therefore, temporary increases in suspended sediment and turbidity would not be expected to affect fish species.

Hazardous Materials and Chemical Spills

Because construction of new shorezone structures and dredging could require heavy equipment to operate near the edge of the lake and barges to operate within the lake, the potential for inadvertent spills of fuels and other hazardous materials to enter Lake Tahoe exists. The potential magnitude of biological effects on fishes resulting from accidental or unintentional contaminant spills depends on a number of factors, including the proximity to the water body; the type, amount, concentration, and solubility of the contaminant; and the timing and duration of the discharge into the water body. A detailed discussion of impacts from construction activities, and regulatory protections, is presented in Impact 15-2 in Chapter 15, "Public Health and Safety." This analysis found a less than significant risk of spills of fuels and other hazardous materials.

Hydrostatic Pressure Waves, Noise, and Vibration

Construction equipment used to install piers and buoys, and construct marinas, as well as dredging could result in temporary periods of elevated pressure waves and create underwater noise and vibration in the lake that could affect fish near construction activities. New piers would be installed from a floating or amphibious barge. In pier reconstruction projects (i.e., the replacement of an existing pier), existing piles would be pulled from the lakebed using a crane or jack mechanism mounted to the barge. Pile installation for each pier would be completed by hand driving or use of a mechanical pile driver on board the floating or amphibious barge. In areas with especially rocky substrate, drilling would be required. If drilling is the method used to install pier piles, a caisson would be used to isolate and dewater the drilling site, which would allow dry pile installation and would minimize hydrostatic pressure-related effects on fish. Bubble curtains would also be used during pile driving activities to keep fish away from the noise source, if required by resource agencies during the permitting process (Ragan, pers. comm., 2018).

Fish use sound for communication, to seek prey, to avoid predators, to orient with certain environmental features, to locate appropriate habitats, and for navigation (Hawkins and Popper 2016). Construction-related noise and particle motion could disrupt fishes' use of sound, which would also disrupt communication, feeding, predator avoidance, and navigation.

The range of potential effects from noise exposure includes impacts on communication, interference to feeding, auditory tissue damage, temporary or permanent hearing loss, physiological stress and immediate or delayed mortality. However, it is also possible that there is no effect to exposure to noise (Popper and Hastings 2009). Studies have shown anthropogenic noise can induce startle and alarm responses in fish (Scholik and Yan 2002) causing fish to flee an area (Boussard 1981; Sabet et al. 2016). Thus, increased noise from construction equipment may temporarily disrupt essential behavior patterns such as feeding and predator escapement. Abiotic and biotic sounds are important to fish and many use acoustic signals to communicate. Noise emanating from construction activities may temporarily reduce auditory sensitivity of some fish species (Scholik and Yan 2002) and interfere with signals that affect communication, behavior and fitness (Popper and Hastings 2009; Purser and Radford 2011).

The noise, vibrations, and pressures produced from pile driving would be much louder than that generated by other construction equipment. Table 5-3 describes the noise thresholds in terms of sound exposure level and root mean square pressure, which are used by the National Marine Fisheries Service (NMFS) and USFWS to determine whether fish may be affected by pile driving. Information utilized by NMFS and USFWS was developed and presented as guidance for use in effects analyses during 2010 (NMFS 2010). However, based on more recent research, it is likely that it takes substantially more acoustical energy to damage fish tissues than those levels proposed in Table -3 (Dahl et al. 2015).

Table 5-3 Underwater Noise Thresholds in Decibels for Fish Exposed to Elevated Levels of Underwater Sounds Produced during Pile Driving

Effect	Metric	Fish Mass	Threshold
Onset of physical injury	Peak pressure	N/A	206 dB (re: 1 μPa)
	Accumulated sound exposure level	≥ 2 g	187 dB (re: 1μPa2•sec)
		< 2 g	183 dB (re: 1μPa2•sec)
Adverse behavioral effects	Root mean square pressure	N/A	150 dB (re: 1 μPa)

Source: NMFS 2010

Sites and Reclamation (2017) suggest that adverse effects to fish resulting from hydrostatic pressure waves and vibration primarily are a function of species morphology and species physiology. Hydrostatic pressure waves could potentially rupture the swim bladders and other internal organs of all life stages of fish in the immediate construction area (as cited in Sites and Reclamation 2017). Additionally, noise and vibration generated by pile driving activities could potentially have sublethal effects on individual fish by causing movement into lower quality habitats (as cited in Sites and Reclamation 2017). Evidence also suggests that lethal effects can occur from pile driving, but accurately analyzing and addressing these impacts, as well as sublethal impacts (e.g., injury, temporary hearing threshold shifts, stress, and behavioral disturbance) is complicated by several factors. Sound levels and particle motion produced from pile driving can vary depending on pile type, pile size, substrate composition, and type of equipment used.

Single strike levels associated with different pile materials ranges in sound from 177 to 212 dB at 33 feet from pile driving (Caltrans 2015). Noise from installation of the anchor posts may cause fish to temporarily avoid the area immediately adjacent to the pile-driving activity. The mostly likely response is that fish would swim away from the area of noise. However, if a fish were to remain immediately next to an area with repeated pile driving, the noise has been found to affect oxygen uptake of fish and increase blood cortisol levels (e.g., Bruintjes et al. 2016). A recent laboratory study found as few as eight pile strikes caused swim bladder injuries to Striped Bass (Casper et al. 2017). Although these studies suggest noise can affect certain fish species, there are clearly species-specific differences concerning acoustical impacts.

Alternative 1: Proposed Shoreline Plan

Under Alternative 1, 2,116 new moorings; 10 public piers; 128 private piers; and two public boat ramps would be allowed, along with new dredging under specific circumstances. Construction activity could occur in areas of prime or marginal fish habitat, which are areas of the lake that fish individuals are most likely to occur and therefore areas where fish would be most likely to experience the effects from construction. Alternative 1 would continue the prohibition on new structures in stream mouth protection areas and would phase implementation of piers according to a schedule of permitting. Phased implementation of pier buildout would limit construction-related effects by preventing spatial or temporal clustering of construction activities. Similarly, it is expected that allocation of other shoreline structures, redevelopment of structures, and expansion of marinas would be naturally phased as the plan is implemented through buildout in year 2040.

Construction activities could result in behavioral and physiological effects on fish species, as well as mortality of individual fish. Specific construction-related effects on fish are dependent on the proximity of individuals to construction locations, the duration of construction activities, and the type of activity. Although construction locations, timing, and durations are not currently known, individual construction efforts would occur in a small area and over a short period. The construction footprint of a pier within the lakezone is relatively small due to pilings being placed by pile drivers which push the piling into the substrate but do not substantially disturb the substrate around the piling. A very conservative construction footprint was estimated to be an additional two-thirds of the area of the pilings. Under Alternative 1, approximately 12 piers would be constructed during each 2-year period. Conservatively, this would result in a likely maximum of 12 simultaneous pier constructions along the 72-mile shoreline. The construction footprint of structures would be exceedingly small relative to the approximately 6,136 acres of prime fish habitat, and 7,706 acres of marginal fish habitat. Construction disturbance footprints for all shorezone structures can be measured in square footage of disturbance, while the amount of fish habitat is best measured in acres. Buoy placement would require almost no disturbance of substrate and would be almost entirely limited to the size of the anchor systems. Altogether, construction associated with full buildout of the Shoreline Plan would account for an estimated 0.005 percent of prime fish habitat, 0.004 percent of marginal fish habitat, and 0.002 percent of the total fish habitat (Table 5-4). This level of disturbance would be minor for all species considered.

Table 5-4 Construction Footprints for Piers and Ramps under Alternative 1

	Structure footprint (sq. ft.)	Estimated construction footprint (sq. ft.)	Construction in prime habitat (%)	Construction in marginal habitat (%)	Construction in all habitat types (%)
Piers (138)	2,084	3,126	0.0012	0.0009	0.0005
Buoys (2,006)	8,024	8,024	0.0030	0.0024	0.0013
Boat ramps (2)	1,500	3,001	0.0011	0.0009	0.0005
Total disturbance	**11,608**	**14,151**	**0.0053**	**0.0042**	**0.0023**

Note: Methodology for determining the construction footprint is described in Section 5.4.2, "Methods and Assumptions."

Source: Compiled by Ascent Environmental in 2018

Even though the overall construction footprint of buildout would be small, and would therefore have little impact on fish located in these areas, TRPA has provided resource protection provisions associated with the Shoreline Plan (Table 2-3), and requires regulatory resource protection measures per the *TRPA Best Management Practices Handbook* and the Standard Conditions of Approval for Shorezone Projects, including the following:

- implement pier design standards, to limit the size of piers and corresponding construction footprint;
- maintain stream mouth protection zones and establish shoreline preservation areas to help minimize disturbance in migration and rearing habitat;
- require use of turbidity curtains and caissons during pier pile installation; and
- require barges to carry a spill containment kit to minimize impacts associated with accidental chemical spills.

Lahontan Cutthroat Trout

Nearshore construction activities under Alternative 1 have little to no potential to adversely affect adult and subadult LCT because they occupy habitats near the lake bottom in deep waters through the year. Adult LCT occurrence in nearshore habitat would primarily occur during spawning migrations into tributary streams, which generally occurs from February through July. However, TRPA regulations require a 200-foot buffer limiting construction near stream mouths which would provide protection from potential construction impacts for migrating LCT.

Alternative 1 may affect YOY LCT, because YOY move into the vegetated nearshore environment of the lake after hatching in tributary streams. Construction-related effects to migrating YOY LCT would be minimal because: 1) they would move laterally along the shoreline, away from construction disturbance (i.e., turbidity or noise), to nearshore areas of the lake that are unaffected, and construction disturbance would be temporary in nature. Because LCT typically do not use nearshore habitats and because any construction-related impacts on LCT that may occur would be minor, construction activities in Lake Tahoe under Alternative 1 would not alter TRPA's threshold standard for LCT.

Mountain Whitefish

Adult and subadult mountain whitefish generally occupy habitats near the lake bottom in deep waters, with adults moving into nearshore habitat primarily during spawning migrations, which generally occurs from October through early December (outside the typical May 1 through October 15 construction period). YOY mountain whitefish move into the vegetated nearshore environment of the lake within several weeks of hatching. Construction-related effects to mountain whitefish would be minimal for the reasons effects on LCT would be minimal.

Lahontan Lake Tui Chub

Nearshore construction activities under Alternative 1 have the potential to affect Lahontan Lake tui chub. Adult Lahontan Lake tui chub spawn in nearshore environments and all life stages of the *pectinifer* subspecies spend time foraging in the nearshore environment. The *obesa* Lahontan Lake tui chub spends most of its life in the pelagic zone of the lake. Therefore, the *obesa* Lahontan Lake tui chub occurs only in the nearshore environment for spawning and for rearing during their first summer after hatching. Lahontan Lake tui chub egg incubation occurs in nearshore areas where eggs adhere to aquatic vegetation or the substrate, and thus construction activities here could result in mortality of a very small percentage of Lahontan Lake tui chub eggs. However, construction-related effects that could occur to Lahontan lake tui chub would be minimal because (1) adult and subadult *obesa* Lahontan Lake tui chub generally feed outside of the nearshore environment; (2) adult *pectinifer* Lahontan Lake tui chub forage in nearshore areas at night when construction activities would not coincide with foraging; (3) spawning generally occurs at night and in stream mouths, which would not be affected by construction; and (4) YOY fishes utilizing nearshore areas under construction would be expected to move laterally along the shoreline, away from construction disturbance (i.e., turbidity or noise).

Native Nongame Fish (Minnows, Sculpins, Suckers)

Native nongame fishes include Lahontan speckled dace, Lahontan redside shiner, Paiute sculpin, and Tahoe sucker. Although these species are native to Lake Tahoe, none are considered special-status species. Nearshore construction activities under Alternative 1 have the potential to affect native nongame fishes. Adult native nongame fishes all spawn in the nearshore environment and all, except for adult Paiute sculpin, spend most of their life in the nearshore environment. YOY Paiute sculpin feed in the nearshore environment, but as adults and subadults the species is more often associated with deep water aquatic macrophyte beds. Native nongame fish egg incubation occurs in nearshore areas, and thus construction activities here could result in mortality of a very small percentage of native nongame fish eggs. However, these effects would minimal because they would be temporary and affect a very small amount of the available habitat, and for the following reasons:

- Adult and subadult Paiute sculpin generally feed in deeper portions of the lake, outside of the nearshore environment.
- Adult Lahontan redside shiners, Lahontan speckled dace, and Tahoe suckers utilizing nearshore areas under construction would be expected to move laterally along the shoreline, away from construction disturbance.
- Adult Lahontan redside shiners and Lahontan speckled dace spawning typically occurs at night when construction activities would not occur.
- Adult Paiute sculpin and Tahoe suckers can spawn in stream mouths and tributaries, which would not be affected.

Coldwater Game Fish

Coldwater game fishes include lake trout, kokanee, brown trout, rainbow trout, and brook trout. Although these species are not native to Lake Tahoe and are not special-status species, they are important to recreational anglers. Adult coldwater game fish spawning and egg incubation would not be affected because these species spawn in tributary streams. Lake trout exclusively inhabit the pelagic, deep water areas of the lake year-round and would not be affected by nearshore construction activities.

Nearshore construction activities have little to no potential to adversely affect adult and subadult coldwater game fish because they generally occupy habitats in deep waters. Kokanee and brook trout occurrence in the nearshore habitat would primarily occur during spawning migrations into tributary streams and construction activity would not occur within 200 feet of stream mouths. Adult rainbow trout and brown trout use the nearshore environment at night for feeding and during their spawning migrations into tributary streams. These times and locations would not coincide with construction activities.

YOY coldwater game fish move into the vegetated nearshore environment of the lake after hatching in tributary streams and rear in nearshore habitats prior to moving into deeper water as they grow larger. However, these effects would minimal because YOY fishes would move away from construction disturbance, construction disturbance areas in fish habitat are very small (Table 5-4), and construction disturbance would be temporary in nature.

Warmwater Game Fish

Warmwater game fishes include largemouth bass, smallmouth bass, bluegill, crappie, and brown bullhead. These species are not native to Lake Tahoe and are popular recreational species in some areas of the lake (e.g., Tahoe Keys). Nonetheless, warmwater game fish are generally considered undesirable invasive species in Lake Tahoe and eradication programs are in effect and would continue under Alternative 1. Construction disturbance to warmwater game fish would not be considered an adverse environmental impact.

Summary of Alternative 1 Effects

All species evaluated could be susceptible to construction-related impacts under Alternative 1, except lake trout, which are not found in the nearshore. However, based on life history characteristics, habitat use for the species evaluated, resource protection provisions associated with the Shoreline Plan, additional avoidance and minimization measures implemented for the protection of fish and aquatic biological resources, significant adverse impacts would not be expected to occur to any of the lake's fish populations. Moreover, construction activities associated with placement of shorezone structures would be required to implement resource protection provisions (Table 2-3 in Chapter 2, "Description of Proposed Project and Alternatives"), and to adhere to the provisions of the Standard Conditions of Approval for Shorezone Structures and the *TRPA Best Management Practices Handbook*. The impacts from construction activities resulting from implementation of Alternative 1 would be **less than significant** for all species and guilds evaluated.

Alternative 2: Maintain Existing TRPA Shorezone Regulations (No Project)

Under Alternative 2, there would be no cap on the number of structures permitted; however, structure placement would be limited to areas outside of prime fish habitat and stream mouth protection areas. Estimated numbers of new structures include: 4,871 buoys; 1,897 slips; 476 piers; six boat ramps; two marinas, and 168 private boat lifts. Alternative 2 would maintain existing development standards.

Construction-related impacts under Alternative 2 would be similar to those identified under Alternative 1; however, impacts would likely occur more frequently and with greater intensity because more structures would be allowed. Additionally, Alternative 2 would not provide provisions for phased implementation of pier projects, which could result in many piers being constructed during a single season.

Estimated construction-related disturbance under Alternative 2 is presented in Table 5-5. The maximum area of disturbance estimated from construction of shorezone structures under Alternative 2 is 39,244 sq. ft. or about 0.01 percent of TRPA-designated marginal habitat, which constitutes 0.007 percent of all fish habitat.

Shorezone construction activities under Alternative 2 would have minimal potential to adversely affect the species considered in this impact for the same reasons discussed under Alternative 1. This would lead to a **less-than-significant** impact from construction-related activities on aquatic species.

Table 5-5 Construction Footprints for Piers and Ramps under Alternative 2

	Structure Footprint (sq. ft.)	Estimated Construction Footprint (sq. ft.)	Construction in Prime Habitat (%)	Construction in Marginal Habitat (%)	Construction in All Habitat Types (%)
Piers (476 multiple-use)	7,173	10,760	n/a	0.0032	0.0018
Buoys (4,871)	19,484	19,484	n/a	0.0058	0.0032
Boat ramps (6)	4,500	9,000	n/a	0.0027	0.0015
Total disturbance	**31,157**	**39,244**	**n/a**	**0.0117**	**0.0065**

Note: Methodology for determining the construction footprint is described in Section 5.4.2, “Methods and Assumptions.”

Source: Compiled by Ascent Environmental in 2018

Alternative 3: Limit New Development

Under Alternative 3, new structures to be constructed include: 365 additional moorings, five new public piers; 86 additional private piers; and one new boat ramp. Like Alternative 1, marina expansion would be allowed under Alternative 3 if coupled with environmental improvements. Under Alternative 3, new structures would be allowed within TRPA-designated prime fish habitat but would be prohibited in stream mouth protection areas. The alternative would regulate the rate of new pier approvals to eight every 2 years, limiting the temporal and spatial effects from construction. While construction activities would occur in multiple areas and at different times, local increases in construction-related turbidity and noise could occur within the shorezone.

Construction-related impacts under Alternative 3 would be similar to those identified under Alternative 1. However, under Alternative 3 construction of shorezone structures would occur less frequently, and likely with less intensity than under Alternative 1 because Alternative 3 would permit fewer structures. Estimated construction-related disturbance under Alternative 3 is presented in Table 5-6. The maximum area of construction disturbance estimated from construction of shorezone structures under Alternative 3 is 4,757 sq. ft., or a maximum of 0.002 percent of prime fish habitat, 0.001 percent of marginal fish habitat, and 0.0008 percent of the total fish habitat.

Table 5-6 Construction Footprints for Piers and Ramps under Alternative 3

	Structure Footprint (sq. ft.)	Estimated Construction Footprint (sq. ft.)	Construction in Prime Habitat (%)	Construction in Marginal Habitat (%)	Construction in All Habitat Types (%)
Piers (91)	1,371	2,057	0.0008	0.0006	0.0003
Buoys (300)	1,200	1,200	0.0004	0.0004	0.0002
Boat ramps (1)	750	1,500	0.0006	0.0004	0.0002
Total disturbance	**3,322**	**4,757**	**0.0018**	**0.0014**	**0.0008**

Note: Methodology for determining the construction footprint is described in Section 5.4.2, “Methods and Assumptions.”

Source: Compiled by Ascent Environmental in 2018

Shorezone construction activities under Alternative 3 would have minimal potential to adversely affect the species considered in this impact discussion for the same reasons discussed under Alternative 1. This would lead to a **less-than-significant** impact from construction-related activities on aquatic species.

Alternative 4: Expand Public Access and Reduce Existing Development

The goal of Alternative 4 is to expand public access by providing new public piers, and to reduce the overall number of existing shoreline structures. This alternative would allow 15 new public piers and no other new shoreline structures. The alternative would include transfer ratios that would allow some private shoreline structures to be removed and reconstructed in different locations with a 2:1 reduction in the number of structures (e.g., a new private pier could be constructed if two existing piers are removed). Alternative 4 would include the same pier construction timing, density, and design requirements as Alternative 3. Although only reconstruction projects and 15 new piers would be allowed under Alternative 4, it would be possible for increased turbidity and noise to occur within the shorezone during construction.

Construction-related impacts under Alternative 4 would be similar to those identified under Alternative 1. However, under Alternative 4 construction of shorezone structures would occur less frequently, and with less intensity than under Alternative 1 because Alternative 4 would permit fewer structures. Estimated construction-related disturbance under Alternative 4 is presented in Table 5-7. The maximum area of disturbance estimated from construction of shorezone structures under Alternative 4 is 339 sq. ft. or a maximum of 0.0001 percent of prime fish habitat, 0.0001 percent of marginal fish habitat, and 0.0006 percent of total fish habitat.

Table 5-7 Construction Footprints for Piers and Ramps under Alternative 4

	Structure Footprint (sq. ft.)	Estimated Construction Footprint (sq. ft.)	Construction in Prime Habitat (%)	Construction in Marginal Habitat (%)	Construction in All Habitat Types (%)
Piers (15 public)	226	339	0.0001	0.0001	0.00006

Note: Methodology for determining the construction footprint is described in Section 5.4.2, “Methods and Assumptions.”

Source: Compiled by Ascent Environmental in 2018

Shorezone construction activities under Alternative 4 would have minimal potential to adversely affect the species considered in this impact discussion for the same reasons discussed under Alternative 1. This would lead to a **less-than-significant** impact from construction-related activities on aquatic species.

Mitigation Measures

No mitigation is required.

Impact 5-4: Permanent habitat modification

Permanent habitat modification could affect all species evaluated except lake trout because they do not utilize nearshore habitats. Impacts on species that could use nearshore habitats would be greatest on native nongame fish, including Lahontan Lake tui chub. Impacts on special-status salmonids, including LCT and mountain whitefish, as well as other coldwater game fish species, would generally be limited to YOY juveniles using nearshore areas for rearing. Under all Shoreline Plan alternatives, impacts resulting from permanent habitat modification would be small relative to TRPA-designated fish habitat, including prime fish habitat. Additionally, based on the life history characteristics and habitat use for the species evaluated, impacts would be minimal for any fish species. Therefore, implementation of the Shoreline Plan alternatives would be l**ess than significant** for all species evaluated.

The Shoreline Plan alternatives would result in the construction and placement of new shorezone structures, and redevelopment of existing structures in the shorezone. These new structures, including piers, buoys, boat slips, boat lifts, boat ramps, and marinas could cause permanent habitat modification, which could result in impacts on fish and aquatic resources. The primary impact mechanisms that could result in permanent habitat modification and result in impacts on fish and aquatic resources are direct habitat alteration, improved conditions for AIS, and changes to predator-prey interactions, as described below.

Direct Habitat Alteration

Placement of new structures, including piers, marinas, boat ramps, and mooring buoys would permanently alter the nearshore habitat of Lake Tahoe. Some new structures would result in the permanent loss of habitat (e.g., buoy anchors, boat ramps, and pier pilings) and some new structures would result in the permanent alteration of the habitat, such that habitat conditions would be expected to change from baseline conditions (e.g., overwater shading from piers).

Marina development would alter habitat by creating artificial channels that could reduce circulation, increase water temperatures, and create habitat for invasive species. Marinas in Lake Tahoe experience elevated water temperatures and changes in water quality due to a lack of mixing with open water, which results in habitat conditions that are suitable for nonnative warmwater invasive fishes and other invasive aquatic organisms.

Over-water structures, such as piers and docks, generally limit light available to phytoplankton and submerged aquatic vegetation, and thereby reduce primary productivity (Bryan and Scarnecchia 1992). Reduced available light is a beneficial effect for preventing the spread of invasive plants such as Eurasian Milfoil but could negatively affect the native macrophyte community. Additionally, native fish species, including Lahontan redside shiners are well adapted to ultraviolet radiation (UVR) intensities present in most of Lake Tahoe's nearshore area (Gevertz et al. 2012). Over-water structures introduce additional shade to the nearshore area, and thus could decrease optimal habitat in the immediate location of a shade-generating structure for native species such as Lahontan redside shiners that prefer clear nearshore waters for spawning.

Studies have shown that piers can result in a reduction in macroinvertebrate abundance (Garrison et al. 2005). Additionally, bass and other nonnative warmwater game fish species generally demonstrate an affinity for structural elements and utilize docks and piles for cover, in addition to vegetation (Kahler et al. 2000). If piers are installed in areas where water temperature conditions are suitable for warmwater game fish species, such as those found in marinas, warmwater species could colonize piers, docks, slips, and other structures and prey on native species using adjacent areas.

In many lakes, extensive macrophyte beds provide complex habitat for nearshore species. However, in Lake Tahoe rocky substrates also provide important habitat. Pier piles would remove substrate immediately where they are installed but would not broadly permanently remove large areas of substrate, so this complex habitat would still be available for nearshore fish species. Nonetheless, studies have shown that piers have limited to no impact on spawning by Lake Tahoe's native fish populations and that impacts can be mitigated by placing suitable substrates in other areas (Beauchamp et al. 1994a; Allen and Reuter 1996). Additionally, Beauchamp et al. (1994a) found that piers had no effect on densities of native nearshore fishes and that the shaded areas provided cover for some species.

Improved Conditions for AIS

Placement of new structures associated with the Shoreline Plan and alternatives could alter habitat such that it would provide improved conditions for AIS, which could result in permanent alterations to native species and recreationally important coldwater game fish species habitat use.

New surface areas and pilings would create shade and structural habitat for nonnative warmwater game fish, including largemouth bass and other sunfishes in Lake Tahoe's nearshore zone. Warmwater game fish in Lake Tahoe have less natural UVR protection than native fish such as Lahontan redside shiners (Gevertz et al. 2012; Tucker and Williamson 2014). A substantial nesting colony of bluegill occurs in the Tahoe Keys where extensive macrophyte growth and turbid waters provide nest shading. Researchers hypothesize that bluegill and bass need this type of shading to protect their larvae from UVR (Gevertz et al. 2012; Tucker and Williamson 2014). Structural features (natural or artificial) are also important for spawning bass (Kahler et al. 2000). For example, in Lake Sammamish, Washington, smallmouth bass were found to build nests close to piers or other artificial structures (Kahler et al. 2000). Additionally, structures provide cover that allows bass and other warmwater game fish to ambush prey. Specifically, these warmwater game fish are ambush predators, which utilize extensive cover to hide and attack unsuspecting prey.

Overall, placing structures in Lake Tahoe provides suitable shade and ambush habitat for warmwater game fishes if they would be located in areas where water temperatures are suitable for these species. However, warmwater game fish populations are primarily located in the Tahoe Keys where additional structures likely would not appreciably increase available habitat. Nonetheless, structures located near the smaller satellite populations of warmwater game fishes in other parts of the lake could provide additional suitable habitat for these species.

Because of their locations, design layouts, and the number and types of structures, marinas generally experience elevated water temperatures during the summer months. Additionally, water does not mix well between marinas and other parts of the lake. Marinas also experience higher densities of recreational boating use than many areas of the lake. Thus, marinas can facilitate the invasion of nonnative plants, crayfish, and other shellfish, which provide food and habitat for warmwater fish species (Chandra et al. 2009).

Lake Tahoe warmwater game species are currently supported by elevated temperatures and nonnative macrophytes, which occur more often in marinas than in other parts of the lake (Chandra et al. 2009). Tahoe Keys exemplifies how marinas lead to increased AIS. Largemouth bass, bluegill, and nonnative aquatic plant species, including Eurasian milfoil and curly leaf pondweed dominate the Tahoe Keys. The prevalence of these nonnative AIS has reduced the abundance and distribution of native species in the Tahoe Keys. Specifically, native minnows that were widespread in the Tahoe Keys have decreased substantially in abundance due to the expansion of suitable habitat for warmwater fishes (Chandra et al. 2009).

Construction of new marinas under Alternative 2, or expansion of existing marinas under alternatives 1 and 3 would be expected to promote increases in the abundance and distribution of warmwater game species by increasing thermal suitability of nearshore habitat for nonnative warmwater game fishes, reducing water circulation in the area, and allowing the colonization and spread of nonnative aquatic vegetation and shellfish. These effects would be reduced because existing AIS detection, control, and eradication efforts for warmwater predators would continue under all alternatives.

<u>Altered Predator-Prey Interactions and Predation Potential</u>

Shoreline development, including placement of piers, can alter predator-prey dynamics (Lange 1999) and reduce biological diversity (Garrison et al. 2005). Overwater manmade structures modify the behavior of both predator and prey species and, therefore, foraging and associated growth and survival can also be affected. Shade cast from over-water structures limits light available for photosynthesis, which could affect primary productivity that supports the food-web of nearshore fish species. For example, a study evaluating fishing pier impacts in lakes found that insect numbers were three times lower under piers compared to open sites away from piers (Garrison et al. 2005). Shade and other habitat changes created by piers can also alter the composition of invertebrate species by reducing abundances of larger species (Duffy-Anderson and Able 2001). Species such as salmonids can modify their prey choices based on prey abundance (Rondorf et al. 1990) but decreases in food sources due to shoreline development may reduce juvenile growth (Sobocinski et al. 2010). Reduced light also affects fishes' ability to detect prey (Munsch et al. 2014). For visual predators, such as salmonids, poor quality habitats under manmade structures can inhibit feeding and may suppress salmonid growth (Abel and Anderson 2005).

In-water structures offer multiple benefits for predatory fishes. Artificial structures placed within a lake's littoral zone can benefit ambush or habituation foraging strategies for warmwater game fishes. New surface areas and pilings would create shade, which provides overhead cover and allows predatory fish to remain hidden. Shaded areas increase a predator's capture efficiency by creating a light/dark interface that allows ambush predators to remain in a darkened area and watch for prey to swim against a bright, highly visible background. Predators are able to see sunlit prey more than 2.5 times as far as a sunlit fish are able to see into a shaded area (Helfman 1981). Therefore, juvenile salmonids and small native fishes face increased predation pressures when swimming around these structures (Kahler et al. 2001). Furthermore, native predators such as piscivorous birds can also benefit from the overwater structures, which creates additional predatory pressures on native fishes and coldwater game species.

<u>Alternative 1: Proposed Shoreline Plan</u>

Under Alternative 1, two boat ramps 2,116 moorings; and 138 piers could be constructed in the shorezone. While the total number of allowed moorings is 2,116, it is estimated that approximately 100 of these would be slips and boat lifts, which would be installed in existing marinas (boat slips) and on piers (boat lifts), reducing potential impacts on fish habitat. New structures would be allowed within TRPA-designated prime fish habitat; however, the prohibition on new structures in stream mouth protection areas would be maintained. Alternative 1 would also provide incentives to encourage the relocation of existing piers from stream mouth protection areas, by allowing relocated single-use piers to qualify for multiple-use design standards and offering upland scenic credits.

Structures would increase shaded habitat by 0.77 acre, which is approximately 0.01 percent of available TRPA-designated prime fish habitat or 0.005 percent of all available TRPA-designated habitat types. Substrate loss would be limited to the area of the piles for each pier, anchors for each buoy, and area of each boat ramp. These areas of permanent disturbance are very small (Table 5-4) and would have an extremely small effect in terms of the overall habitat acreage for all fish species considered below.

If new structures are proposed in areas designated by TRPA as prime fish habitat, an applicant would be required to replace affected substrate at a 1.5:1 ratio. Substrate replacement could occur on-site or elsewhere, adjacent to existing prime fish habitat and would involve the creation of physical habitat by placing gravel, cobble, or boulder substrate. Replaced substrate would be of the same type as that affected by the Shoreline Plan.

Lahontan Cutthroat Trout

Nearshore structures under Alternative 1 have little to no potential to adversely affect adult and subadult LCT because they occupy deep, open water habitats except during spawning migrations to tributary streams. Alternative 1 may affect YOY LCT, because YOY move into the vegetated nearshore environment of the lake after hatching in tributary streams. These effects to migrating YOY LCT would be minimal because the area of habitat disturbance would be very small relative to the available habitat and for many of the same reasons that construction-related effects would be minimal (see Impact 5-3).

Mountain Whitefish

Nearshore structures under Alternative 1 have little to no potential to adversely affect adult and subadult mountain whitefish because they occupy deep, open water habitats except during spawning migrations to tributary streams. Alternative 1 may affect YOY mountain whitefish, because YOY move into the vegetated nearshore environment of the lake after hatching in tributary streams. These habitat modification-related effects to YOY mountain whitefish would be minimal because the area of habitat disturbance would be very small relative to the available habitat and for many of the same reasons that construction effects would be minimal (see Impact 5-3).

Lahontan Lake Tui Chub

Nearshore structures under Alternative 1 have the potential to affect Lahontan Lake tui chub. Adult Lahontan Lake tui chub spawn in nearshore environments and all life stages of the *pectinifer* subspecies spend time foraging in the nearshore environment. The *obesa* tui chub spends most of its life in the pelagic zone of the lake. Therefore, the *obesa* tui chub occurs only in the nearshore environment for spawning and as foraging and rearing YOY. Nearshore structures could affect rearing YOY Lahontan Lake tui chub These habitat modification-related effects to Lahontan Lake tui chub would be minimal because the area of habitat disturbance would be very small relative to the available habitat and for many of the same reasons that construction effects would be minimal (see Impact 5-3).

Native Nongame Fish (Minnows, Sculpins, Suckers)

Native nongame fishes include Lahontan speckled dace, Lahontan redside shiner, Paiute sculpin, and Tahoe sucker. Although these species are native to Lake Tahoe, none are considered special-status species. These fish species are part of the nearshore assemblage and spend portions of their life cycle in the nearshore environment, including spawning. Adult native nongame fishes all spawn in the nearshore environment and all but adult and subadult Paiute sculpin spend most of their life in the nearshore environment. YOY Paiute sculpin feed in the nearshore environment, but as adults and subadults the species is more often associated with deep water aquatic macrophyte beds. Nearshore structures could affect native nongame fish species but these effects would be minimal because the area of habitat disturbance would be very small relative to the available habitat and for many of the same reasons that construction effects would be minimal (see Impact 5-3).

Coldwater Game Fish

Coldwater game fishes include lake trout, kokanee, brown trout, rainbow trout, and brook trout. Lake trout exclusively inhabit the pelagic, deep water areas of the lake year-round and would not be affected by nearshore structures. Nearshore structures generally have little to no potential to adversely affect adult and subadult coldwater game fish because they generally occupy habitats in deep waters. Kokanee and brook trout occurrence in nearshore habitat would primarily occur during spawning migrations into tributary streams. Adult rainbow trout and brown trout use the nearshore environment at night for feeding and during their spawning migrations into tributary streams.

YOY coldwater game fish move into the vegetated nearshore environment of the lake after hatching in tributary streams and rear in nearshore habitats prior to moving into deeper water as they grow larger. Nearshore structures could affect foraging adult rainbow trout and brown trout, and other coldwater game fish rearing YOY, Overall, these habitat modification-related effects to coldwater game fish would not be substantially adverse to the lake's coldwater game fish populations because the area of habitat disturbance would be very small relative to the available habitat and for many of the same reasons that construction effects would be minimal (see Impact 5-3).

Summary of Alternative 1 Impacts

Permanent habitat modification under Alternative 1 could affect all species evaluated except lake trout, which do not utilize nearshore areas where shoreline structures would occur. However, based on the relatively small amounts of permanently modified habitat, a 1.5:1 habitat replacement for prime fish habitat, life history characteristics and habitat use for the species evaluated, significant adverse impacts would not be expected to occur to any of the lake's fish populations. Effects resulting from permanent habitat modification under Alternative 1 would not:

- reduce the ability to attain or maintain TRPA threshold standards for LCT, lake habitat, or AIS;
- substantially change the diversity or distribution of any fish species in Lake Tahoe;
- reduce the number or viability of any fish species in Lake Tahoe;
- result in a barrier to any fish species movement in Lake Tahoe; or
- substantially reduce the suitability of available habitat for any fish species in Lake Tahoe.

Based on the findings above, Alternative 1 would result in a **less-than-significant** impact for all fish species and guilds evaluated.

Alternative 2: Maintain Existing TRPA Shorezone Regulations (No Project)

Under Alternative 2, new structures would include an estimated 4,871 buoys; 1,897 slips; 476 piers; six boat ramps; two marinas, and 168 private boat lifts, all of which would be placed outside of prime fish habitat and stream mouth protection areas.

The effects of permanent habitat modification associated with structures constructed under Alternative 2 would be similar to those identified under Alternative 1. However, under Alternative 2, placement of structures in TRPA-designated prime fish habitat would not be allowed. Nonetheless, under Alternative 2 impacts associated with permanent habitat modification would be greater than under Alternative 1 because Alternative 2 includes more structures and does not include many of the resource protection provisions included under Alternative 1.

Some effects resulting from permanent habitat modification under Alternative 2 could occur to all species evaluated except lake trout, which do not utilize nearshore areas where shoreline structures would occur. Effects resulting from permanent habitat modification under Alternative 2 would be largely the same as those listed in the summary of Alternative 1, above; therefore, Alternative 2 would be **less than significant** for all species and guilds evaluated.

Alternative 3: Limit New Development

Under Alternative 3, new structures would include: 365 additional moorings, five new public piers; 86 additional private piers; and one new boat ramp. Like Alternative 1, marina expansion would be allowed if coupled with environmental improvements. Under Alternative 3, new structures would be allowed within TRPA-designated prime fish habitat. However, there would continue to be a prohibition on new structures in stream mouth protection areas.

Impacts associated with placement of structures in the nearshore would be minimized because all piers would be required to comply with pier design and density standards. Additionally, new structures would be prohibited in stream mouth protection areas and Alternative 3 would provide new incentives to encourage the relocation of existing piers from stream mouth protection areas by allowing relocated single-use piers to qualify for multiple-use design standards, and by offering upland scenic credits for relocated piers.

Structures would increase shaded habitat by 0.77 acre, which is approximately 0.01 percent of available TRPA-designated prime fish habitat or 0.005 percent of all available TRPA-designated habitat types. Substrate loss would be limited to the area of the piles for each pier, anchors for each buoy, and area of each boat ramp. These area of permanent disturbance is very small (Table 5-6) and would have an extremely small effect in terms of the overall habitat acreage for all fish species considered.

If new structures are proposed in areas designated by TRPA as prime fish habitat, an applicant would be required to replace affected substrate at a 1.5:1 ratio. Substrate replacement could occur on-site or elsewhere adjacent to existing prime fish habitat and would involve the creation of physical habitat by placing gravel, cobble, or boulder substrate. Replaced substrate would be of the same type as that affected by the structure.

Some effects resulting from permanent habitat modification under Alternative 3 could occur to all species evaluated except lake trout, which do not utilize nearshore areas where shoreline structures would occur. Effects resulting from permanent habitat modification under Alternative 3 would be the same as those listed in the summary of Alternative 1; therefore, the impact of Alternative 3 would be **less than significant** for all species and guilds evaluated.

Alternative 4: Expand Public Access and Reduce Existing Development

Alternative 4 would allow 15 new public piers and no other new shoreline structures. The alternative would include transfer ratios that would allow some private shoreline structures to be removed and reconstructed in different locations, as long as the project resulted in a 2:1 reduction in the number of structures.

Although specific locations of structures are not currently known, new structures including piers would generally be distributed around the lake and not located closely together in specific areas. No new buoys, boat ramps, boat slips, boat lifts, or marinas would be placed in Lake Tahoe under Alternative 4.

Structures would increase shaded habitat by 0.77 acre, which is approximately 0.01 percent of available TRPA-designated prime fish habitat or 0.005 percent of all available TRPA-designated habitat types. Substrate loss would be limited to the area of the piles for each pier, anchors for each buoy, and area of each boat ramp. These area of permanent disturbance is very small (Table 5-7) and would have a vanishingly small effect in terms of the overall habitat acreage for all fish species considered. Impacts associated with placement of piers in the nearshore would be minimized because all piers would have to comply with pier design and density standards. Additionally, new piers would be prohibited in stream mouth protection. If new piers are proposed in prime fish habitat, an applicant would be required to replace affected substrate at a 2:1 ratio.

Some effects resulting from permanent habitat modification under Alternative 4 could occur to all species evaluated except lake trout. Effects resulting from permanent habitat modification under Alternative 4 would be the same as those listed in the summary of Alternative 1; therefore, the impact associated with Alternative 4 would be **less than significant** for all species and guilds evaluated.

Mitigation Measures

No mitigation is required.

Impact 5-5: Recreation-related impacts

Recreational activities could affect all species evaluated. Effects on species that could use nearshore habitats would be greatest on native minnow species that spawn in nearshore areas, including Lahontan Lake tui chub. Effects on special-status salmonids, including LCT and mountain whitefish, as well as other coldwater game fish species, could occur to adults that utilize open waters of the lake and to YOY juveniles using nearshore areas for rearing. Spawning and egg incubation of special-status salmonids and other coldwater game fish species would not be affected since these species spawn in tributary streams or deep in the lake where they would not be affected by increased boating or recreational angling. Effects under Alternative 2 would be greatest because it would allow the largest number of structures and two new marinas. Thus, under Alternative 2 the capacity for recreational activities such as boating and angling would be highest. Effects under Alternative 4 would be the least because it contains the least number of structures and no increases in boating, relative to baseline. Recreation-related effects under Alternative 1 and Alternative 3 would be intermediate between Alternatives 2 and 4. However, under all the alternatives, recreation-related effects resulting from increased recreational angling and/or boating would be small. Based on the life history characteristics and habitat use for the species evaluated, recreation-related effects would be **less than significant** for all alternatives.

The Shoreline Plan alternatives would result in an increased number of shoreline structures, relative to the baseline. These new structures could increase the number of people that utilize the lake for recreational activities such as angling and boating. The number of shoreline structures (boat ramps and associated parking, buoys, boat lifts, and slips) limits the total capacity for day-use and moored boats on Lake Tahoe. As such, implementation of the Shoreline Plan alternatives would result in differing levels of increased motorized boat use and angling depending on the number of new structures authorized by each alternative. These increases in recreational angling and boating activity could potentially result in affects to fish and aquatic resources in Lake Tahoe. The primary impact mechanisms that could result in recreation-related impacts from increases in boating are increased polycyclic aromatic hydrocarbon (PAH) generation from burning of fuel in boat motors, noise disturbance, propeller strikes and entrainment of fishes, lake bed disturbance, and shoreline parking. The primary impact mechanisms that could result from increased recreational angling are direct harvest, hooking mortality, and water quality effects associated with increased trash and contaminants. In addition, increased boat usage on the lake would result in increased occurrence of boat propellers cutting invasive aquatic macrophytes into fragments that then drift with surface currents to become established elsewhere in the lake. However, this potential impact of the project was assessed separately under Impact 5-1. Each of these impact mechanisms are described in detail below.

<u>Boating</u>

Boat use on Lake Tahoe is seasonal, with nearly all boating activity occurring between May 1 and September 30. Boat use is greatest during summer weekends, with peak boat use occurring during the Independence and Labor Day holiday weekends. Motorized watercraft generally includes powerboats, fishing boats, pontoon boats, and jet skis (Alexander and Wigart 2013). Nonmotorized watercraft generally includes kayaks, stand-up paddle boards, and peddle boats. Along most of Lake Tahoe's nearshore there is no restriction on the size or number of boats allowed. Based on a review of boat registration data and boat inspections conducted during 2015 (the most recent year for which data is available), an estimated total of 13,617 separate motorized watercraft operated on Lake Tahoe at some point during the 2015 boating season (TRPA 2016b).

Polyaromatic Hydrocarbon Generation

Motorized boating can lead to release of petroleum products into the water. Byproducts, from fuel combustion in powered recreational watercraft, can enter the water column through exhaust fumes and other petroleum products can enter the water through direct spills. These petroleum products and combustion byproducts can cause effects to aquatic biota when present at sufficiently high concentrations. The gaseous and particulate phase of exhaust contains hundreds of harmful chemical compounds, including hydrocarbons, carbon oxides, sulfur oxides, nitrogen oxides, and particulate matter. Even at concentrations as low as 1 microgram per liter (Jacobson and Boylan 1973) these chemicals can affect fish by causing liver damage, internal and external lesions, suppression of the immune system, reduction in oxygen uptake efficiency, and, disruption in digestive functions (Balk et al. 1994; Arkoosh et al. 1998; Rudolph et al. 2002; Whitfield and Becker 2014). Tjarnlund et al. (1995, 1996) reported that rainbow trout exposed to low levels of engine exhaust faced sublethal interferences of cellular and physiological processes.

Some of the most significant polluting contaminants of petroleum are the known carcinogens and mutagens, PAHs. PAHs are a group of hydrophobic organic compounds released during the incomplete combustion of fossil fuels, an inherent problem with commonly used two-stroke engines (Mastran et al. 1994). To reduce noise and odor from two-stroke engines, most engine exhaust is emitted directly into the water, thereby efficiently transferring PAHs into the water column. Several studies have linked PAH increases to summertime boat activity (Miller et al. 2003; Lico 2004).

Prior to 1999 most two-stroke vessel engines were carbureted. These high-emission engines have since been replaced with direct fuel injected engines which release much lower levels of gasoline and PAHs into the water. TRPA enacted an ordinance to reduce PAHs, and the only engines currently allowed on Lake Tahoe are four-stroke and direct fuel injection two-stroke engines that meet the U.S. Environmental Protection Agency 2006 emission standards (Lico 2004). However, while the newer direct fuel injected engines offer some benefit with PAH release compared with the older two-stroke engines, significant PAH's are still released by fuel injected two stroke engines. Kado et al. (2000) compared particulate matter emissions from four-stroke engines, direct injection (2-stroke/DI), and carbureted (2-stroke/C) engine during a 67-minute test period. The total amount of PAHs released during the test period was less than 27 micrograms (µg), 3,600 µg, and 1,900 µg for the 4-stroke, 2-stroke/DI and 2-stroke/C engines, respectively. Further, Lico (2004) found PAH concentration and distribution in Lake Tahoe waters were comparable before and after the ban of carbureted two-stroke engines.

Compared to their solubility in water, PAHs are significantly more soluble in organic materials (Klaassen 1996, cited in Miller et al. 2003). Further PAHs have a very short half-life, most less than a day, so they are unlikely to accumulate in the water column. Thus, PAHs tend not to be found in open water and primarily accumulate in sediments, particulate organic matter and bioaccumulate in living organisms, or experience chemical and biological degradation (Rand and Petrocelli 1985, cited in Miller et al. 2003; Meador et al. 1995; van Metre et al. 2000). PAH exposure has been shown to affect the early life stages of many organisms. Due to the accumulation of PAHs in sediment, fish nesting in substrates and sediments may be exposed to PAHs when spawning, as are their eggs.

Because PAHs are easily and rapidly absorbed by organisms, chronic input of PAHs in the same locale, even in low concentrations, may have detrimental effects to juvenile fish (Moles and Marty 2005). Dietary exposure to PAHs has been found to cause liver stress and tumors in rainbow trout (Hyötyläinen and Oikari 1999; Black et al. 1988; Laycock et al. 2000). Bioaccumulation of PAHs have also been found to cause an altered energy balance and reduction in fish weight (Meador et al. 2006; Blanc et al. 2010). The main route of PAH exposure for salmonids is through contaminated prey sources that accumulate PAHs from sediments (i.e., benthic macroinvertebrates, plankton, and other fishes; Johnson et al. 2007). Because PAHs are strongly correlated with sediments, the planktonic pathway may be less of a PAH vector than benthic food sources. Benthic feeders such as the Tahoe sucker, the *obesa* tui chub, and speckled dace frequently come in contact with sediments that contain sediment-adsorbed hydrophobic pollutants and consume benthic invertebrates that may have bioaccumulated PAHs over time. Thus, benthic feeders and piscivorous fish may be at higher risk of PAH exposure than planktonic feeders.

In Lake Tahoe, PAH compounds and their concentrations were found to be highest during summer in areas where boat activity is highest (Lico 2004). Thus, increased PAH inputs are expected with increased boat activity. However, several studies have found that PAHs occur in Lake Tahoe only in extremely low concentrations, except in the Tahoe Keys area, when compared to state and federal standards (Lico 2004; Rowe et al. 2009). Lico (2004) concluded that even with PAHs continuing to enter the lake from boating and other activities, the concentrations are sufficiently low as to pose no toxicity threat to organisms, except potentially in the Tahoe Keys area (Lico 2004). Even with increased future boating activity, PAHs are expected to remain low in Lake Tahoe due to a greater percentage of powered watercraft changing to the lower emission four-stroke engines over time.

Noise Disturbance

TRPA has strict laws on powerboat noise levels, requiring engines to have a maximum noise of 90 A-weighted decibels (dBA) (i.e., the relative loudness of sounds in air pressure as perceived by the human ear) for boats manufactured before January 1, 1993 and 88 dBA for boats manufactured after January 1, 1993 (TRPA 2016a). As discussed above for construction-related impacts, the effects of noise on fish remains poorly studied. Nonetheless, studies suggest that motorboat noise can affect certain fish species. For example, in one study, motorboat noise elevated stress and reduced anti-predator responses of small fish (Simpson et al. 2016). Boat noise may also affect foraging efficiency and energy expenditure (Bracciali et al. 2012). Noise emanating from powerboats also can temporarily reduce auditory sensitivity of some fish species (Scholik and Yan 2002) and interfere with signals that affect communication, behavior, and fitness (Popper and Hastings 2009; Purser and Radford 2011).

Boat noise-related responses vary by species. For example, during the onset of boat noise, smallmouth bass demonstrated a startle response, where they moved from a stationary position to swimming (Pucylowski 2013). Motorboats caused Roach to have higher swimming speeds and to increase their use of the central part of a lake during boating disturbances (Jacobsen et al. 2014). In contrast, in the same study, motorboat noise did not change the behavior of Perch or Pike. Repeated boating noise also did not affect hatching success, fry survival, or growth of the cichlid fish *Neolamprologus pulcher* (Bruintjes and Radford 2014). Studies suggest repeated exposure to noise increases the noise tolerance of certain fish species (Nedelec et al. 2016). As concluded above in the discussion of construction-related impacts (i.e., Impact 5-3) species-specific differences in noise responses exist. Nonetheless, boat noise-related effects on fish in Lake Tahoe could potentially occur.

Propeller Strikes and Entrainment

Increased boating could result in effects to fishes as a result of propeller strikes and entrainment (i.e., capture of organisms in a turbulent flow). Changes in pressure, shear forces, acceleration or deceleration, and direct impacts have the potential to cause injury or mortality to fishes if they encounter boat propellers. Fish mortality caused by physical contact with boat hulls and propellers of small powerboats is rare, but recreational boats operated at high speeds can kill fish (USACE 2004). There have been some reports of fish wounds from powerboat collisions, yet few studies on this topic have been published. It is assumed larger fish are more at risk of direct strikes (Killgore et al. 2011), but it has not been determined how different size classes of fish may be affected (Whitfield and Becker 2014).

Boat propellers may also entrain fish eggs, larvae, invertebrates, phytoplankton and zooplankton, and as a result have more potential to affect fishes indirectly via impacts on food resources than direct propeller strikes (Miranda and Killgore 2013). Therefore, increased boating activity could increase the potential for adverse effects to fish through entrainment of their forage species, such as zooplankton and *Mysis* (Wolter and Arlinghaus 2003; Bickel et al. 2011). However, entrainment from boat propellers is difficult to measure because organisms killed or injured in this manner show no visible scars. The amount of water entrained by a propeller is related to the propeller diameter, the pitch and the slip. Larger boats (Table 5-8) entrain more water and are more dangerous to aquatic biota than smaller boats.

Table 5-8 Characteristics of Recreational Boats

Boat Class	Typical Power	Average Speed (mph)	Typical Propeller Diameter (in)	Typical Propeller Pitch (in)	Typical Propeller Slip	Water Entrained (m^3/mile traveled)	Water Entrained (m^3/s)
Fishing boat	50-hp outboard	16.6	12.25	15	0.3	174	0.08
Pontoon	50-hp outboard	12.3	13	11	0.35	212	0.72
Medium powerboat	100- to 300-hp inboard/outboard	22.8	14	19	0.26	216	1.37
Large cruiser	200- to 500-hp inboard	20	17	17	0.28	329	1.83

Lake Tahoe has an existing 600-foot no-wake zone from the shore around the entire lake and includes a posted speed limit of 5 miles per hour (mph) within the no-wake zone. Boats traveling at a low speed (e.g., ≤5 mph) reduce potential for propeller strikes and entrainment of fish (USACE 2004; Killgore et al. 2011). Fish, such as salmonids and minnows that utilize surface waters may be at higher risk of collision with a propeller than benthic dwelling fish such as *obesa* tui chub, suckers, and catfish. Yet, boats would be moving slowly (less than 5 mph) when utilizing nearshore waters, therefore, direct contact or entrainment in nearshore areas is expected to occur infrequently. However, when boating occurs away from the restricted speed zones, direct hits and entrainment have increased probability of occurrence due to higher rates of speed, but fish densities near the surface away from the nearshore zone are generally lower than that within the nearshore zone. Hence, direct contact or entrainment in open water areas of the lake also are expected to occur infrequently.

Bed Disturbance

Powerboat activity can cause resuspension of bed sediments from boat wakes or direct boat contact. Re-suspension of lake bottom sediments creates turbidity, which decreases water clarity and causes direct effects on fishes in the vicinity of the disturbance. However, this effect usually occurs only in the short term.

Resuspension allows sediments to release nutrients and exposes previously buried sediments and pore water (i.e., water held in interstitial spaces between sediment particles). The exposure of deeper sediments, suspension of fine sediments, and release of pore water results in discharges of nutrients to the waters of Lake Tahoe that often exceed water quality objectives for the lake, and sometimes exceed water quality surface discharge standards (TRPA 2004:5-11).

If bed sediments are contaminated, bed disturbance can cause toxins adhering to sediments to enter the food chain as the toxins become available to benthic organisms. Toxins that are disturbed and become resuspended in the water column also become directly available to pelagic organisms. Thus, disturbance of bottom sediments is a potential pathway for toxins to enter the food chain. Exposure to toxins through food resources has potential to cause bioaccumulation of toxins in fish species. Effects of toxins would depend on types and concentration of the toxins in disturbed sediments. Toxins that may potentially occur in sediments within Lake Tahoe include metals, PAHs, PCBs, and other anthropogenic contaminants (Datta et al. 1998; Heyvaert et al. 2000).

Shoreline Parking

There are numerous piers, slips, marinas, and docks along the lake that provide boat parking. However, some boaters choose to park their boats along the shoreline. Shoreline parking occurs more frequently on busy boating days (i.e., summer holiday weekends) when boat parking structures are full. When parking on the shoreline, boaters generally prefer parking on sandy areas instead of gravel or rocky substrate. Parking on the shoreline can potentially crush eggs or disrupt juveniles or spawning adults. Tui chub are the only fish that spawn in shallow water sandy habitats; however, they are night spawners. Further, tui chub do not build nests and their eggs are not necessarily concentrated into one area (Moyle 2002). Therefore, the likelihood of any given boat crushing numerous fish eggs when it parks in sandy areas is generally low. Nonetheless, tui chub eggs would be subject to movement by wave and wake motion created by boats.

Although sandy beach areas are the most likely shoreline location for boaters to park, on busy days boats may park in high demand areas with rocky substrates. A study in Lake Tahoe on Lahontan redside shiners and Lahontan speckled dace found that shoreline boat parking affected fish only during extreme disturbance days (i.e., Independence Day or Labor Day) (Allen and Reuter 1996). Although Lahontan redside shiners and Lahontan speckled dace typically spawn after dark, the study found that fish occasionally spawn during daytime hours. Thus, boat parking may occasionally disrupt spawning Lahontan redside shiners and Lahontan speckled dace. Allen and Reuter (1996) found a significant drop in egg survival occurred at one spawning site during the Independence Day weekend at a location where boating activity was unusually high. Many boats were parked along the nearshore and were subjected to wakes from boats coming and leaving the area, which caused beached boats to rock and bounce on eggs incubating in the nearshore substrate.

Recreational Angling

Increased recreational angling could occur directly from placement of new shoreline structures, as well as from boats and other watercraft. The placement of piers and increased boating in Lake Tahoe is expected to lead to increased fishing pressure on warmwater game fish, coldwater game fish, and native nongame species. Current fishing regulations would continue to apply the daily limit of five game fish harvested per day, two of which can be lake trout, to anglers. Anglers can have up to 15 mountain whitefish in possession per day. Increased angling may also increase effects on native nongame fish populations such as Lahontan Lake tui chub and Lahontan redside shiners because these fish are used as bait. Increased fishing pressure may also benefit species of concern and coldwater game species through increased harvest of predatory warmwater sport fishes (e.g., largemouth bass and sunfishes).

Increases in fishing pressure may cause increased hooking mortality of coldwater and warmwater game species. Catch-and-release of gamefish is a common recreational practice in Lake Tahoe. Catch-and-release fishing, using hook and line, releases live fish back to waters where they were captured and assumes fish will survive the event unharmed (Arlinghaus et al. 2007). However, significant mortality can result from catch-and-release fishing. Two predominant factors cause hooking mortality: 1) physiological stresses caused by struggle, landing time, handling time, and exposure to air during hook removal and release and, 2) injuries caused by the hook. Hook wounds may appear minor to anglers but damage to gills, throats, eyes or internal organs can be fatal. Hooking injuries, such as eye damage can affect feeding because visually impaired fish could lose the ability to forage competitively and avoid predators (Wright 1972). Infection from pathogens also can occur in hook wounds and lead to reduced immune function and eventual mortality. Mortality from physiological stresses is difficult to identify, but stress can cause fish to become vulnerable to disease, parasites, and predators (Snieszko 1974; Esch et al. 1975).

Estimates of hooking mortality rates are based primarily on immediate or short-term mortality. Because it is difficult to correlate latent mortality to hooking-related physiological stresses, rates are likely higher than those in published studies. A number of factors affect hooking mortality such as the size of a fish, lure type, temperature, hooking location on the fish, and environmental conditions. Use of artificial lures, rather than bait, consistently lowers mortality rates because fish are almost always hooked in areas of the mouth or jaws not contacted by blood vessels (Hooten 2001). Because larger fish are more difficult to handle, higher handling related mortality would be expected with larger fish (Muoneke and Childress 1994).

Warmer water leads to higher activity levels, resulting in longer hooked periods (i.e., longer time to land a hooked fish), energy expenditures, and subsequent build-up of lactic acid and stress hormone levels. For example, rainbow trout hooking mortality rose nearly 50 percent in water temperatures greater than 21°C (Titus and Vanicek 1988). Similarly, cutthroat trout hooking mortality increased as temperatures rose from 3 to 17°C (Titus and Vanicek 1988). Because higher water temperatures are directly correlated with increased hooking mortality (Titus and Vanicek 1988; Wilkie et al. 1996), and nearshore fish are exposed to warmer temperatures in summer months, nearshore species may be more vulnerable to hooking mortality than estimates from previously published studies. Coldwater game fish typically utilize the hypolimnion during the summer, and thus, they would not be exposed to warmer temperatures in the nearshore. However, coldwater game species residing deep within the lake that, once hooked, may be brought to the surface rapidly can also experience adverse physiological effects. Such effects are due to the rapid changes in pressure experienced by the fish as it is reeled from the depths to the boat over a short period of time.

Although studies have investigated fish hooking mortality, none have been conducted in Lake Tahoe. However, hooking mortality studies have been conducted for many fish species that occur in Lake Tahoe. Among salmonids, hooking mortalities range from 0 to 57 percent for brook trout, 0 to 28 percent for brown trout, 0.3 to 48.5 percent for cutthroat trout, 6.98 to 14 percent for lake trout, and 1 to 95 percent for rainbow trout (Muoneke and Childress 1994). Hooking mortality is similar for warmwater species. Studies have found hook mortalities range from 0 to 77 percent for crappies, 0 to 88 percent for bluegill, 3.2 to 40.5 percent for largemouth bass, and 0 to 47.3 percent for smallmouth bass (Muoneke and Childress 1994; Alumbaugh 1996).

Water Quality Effects Associated with Increased Trash and Contaminants

When piers are used for recreational purposes, pollutants, such as liquid and solid waste, could be introduced into the lake. It is also possible that this increased use of the near-shore environment by recreational anglers and boaters would lead to trash entering the surrounding waterways. Potential pollutants may include fish carcasses, food scraps, and plastics. Increased boating can also lead to increased trash and contaminants entering the open waters of Lake Tahoe. The magnitude of potential biological effects resulting from the intentional or unintentional release of pollutants and trash into nearshore and pelagic environments depends the type, amount, concentration, and solubility of the contaminant; and the timing and duration of the waste entering the water body.

There is also the possibility of plastics entering water bodies adjacent to piers or from boating either through intentional discard or accidental release. Plastics are the most common litter in U.S. water bodies, so it is reasonable to assume an increase in plastics entering Lake Tahoe could occur due to increased recreation. Plastic cups, plastic bags and wrapping materials, fast-food wrappers, bottles, and other containers can harm fish through strangulation or consumption. Under environmental conditions larger plastic items can also degrade to microplastics (fragments typically smaller than 5 mm in diameter). Microplastics can then be ingested by aquatic organisms such as fish and may act as vectors for organic pollutants commonly found in plastics (Zarfl et al. 2011). It is reasonable to assume any pollutants or trash would be locally constrained and the volume of the contaminants resulting from spills or dumping would be very small, relative to the amount of surrounding water.

Alternative 1: Proposed Shoreline Plan

Under Alternative 1, new structures would increase recreational activities such as boating and angling in Lake Tahoe. Boating activity would increase by an estimated 16 percent annually. Compared to baseline conditions this would include approximately 765 additional boat trips on a peak day (i.e., summer holiday weekend) and approximately 38,200 additional annual boat trips. Because recreational activities would primarily occur in the summer, impacts would be limited to summer months (May 1 through September 30). Increased boating and other recreational activities could result in behavioral and physiological effects, as well as mortality of individual fish.

Because the specific relationship between increased boating and recreational angling is not known, it is not possible to quantify the amount of additional recreational angling that would occur from increased boating-related activity. Additional recreational angling associated with increased structures also could occur, but the amount of increased angling that could occur due to greater access from shoreline structures is also is not known.

Specific recreation-related effects are dependent on the proximity of individual fish to recreational activities and species-specific responses to increased watercraft activity and recreational angling. Although specific locations of structures are not currently known, new structures including piers, buoys, and boat ramps would generally be distributed around the lake, and not located closely together in specific areas. Thus, new locations for recreational angling would be distributed around the lake, and increased recreational angling resulting from the alternatives would not be concentrated in a specific area of the lake.

Impacts associated with increased boating and recreational fishing would be minimized because of the resource protection measures associated with the Shoreline Plan (Table 2-4 in Chapter 2, “Description of Proposed Project and Alternatives”), which would include the following:

- Boat inspectors would educate watercraft owners and operators during boat inspections about the no-wake zone and appropriate watercraft operations and maintenance, including fueling practices, bilge and sewage operations to prevent discharges into the lake, and appropriate engine tuning and propeller selection to reduce emissions during high-elevation boating.

- Staff at marinas and motorized watercraft rental concessions would receive training on appropriate watercraft operations and maintenance, including fueling practices, bilge and sewage operations, and appropriate engine tuning and propeller selection.

- Staff at marinas and motorized watercraft rental concessions would be required to educate customers about the no-wake zone and appropriate watercraft operations.
- Signs and other public information would be provided at all public boat ramps and at other public access points along the shoreline to educate boaters and other shoreline users about the no-wake zone, AIS prevention strategies, and public safety considerations.
- The no-wake zone would be maintained at 600 feet from the water line and boat speed would continue to be limited to 5 mph lake wide within the no-wake zone.
- Additional funding for nearshore turbidity monitoring and adaptive management actions associated with boat traffic is included in the Shoreline Plan.
- Prohibition of boat beaching in spawning habitat during the spawning season.

Lahontan Cutthroat Trout

Adult LCT inhabit deep water areas of the lake, except during spawning migrations to tributary streams and, thus, would not be affected by nearshore boating activity or angling that occurs from shorezone structures. YOY move into the vegetated nearshore environment of the lake after hatching in tributary streams and rear in nearshore habitat prior to moving into deeper water as they grow larger. Nearshore recreation-related activities under Alternative 1 may affect YOY LCT, because YOY occur in the nearshore environment of the lake for rearing. Open water recreation-related activities under Alternative 1 may affect adult and subadult LCT, because greater open water boating and open water angling would occur under Alternative 1.

Recreation-related effects to LCT would be limited because adult and subadult LCT are open water species that do not generally use nearshore habitat where increased angling from piers and direct contact from boating is anticipated to occur. In addition, adult and subadult LCT generally use the colder hypolimnion in the summer and would not be susceptible to entrainment or propeller strikes. Adult and subadult LCT utilizing open water areas would not be exposed to substantially higher PAH concentrations because increased boating and resulting PAHs would be dispersed throughout the lake, limiting the potential for PAHs to concentrate in specific open water locations. Further, PAHs have a very short half-life and would continue to rapidly disappear from the water column (see Impact 6-4 in Chapter 6, "Hydrology and Water Quality"). Recreational effects on LCT would also be limited for the following reasons:

- LCT spawning occurs in tributary streams. Recreation-related activities in nearshore habitat would not affect spawning activities, spawning habitat, or egg incubation.
- Because YOY LCT would not be expected to use nearshore habitats within marinas, and PAHs from increased boating would be expected to increase mostly in marinas where boat traffic is concentrated and engines do not run at an efficient level, potential increases in PAHs in marinas would not affect YOY LCT.
- YOY LCT utilize vegetated nearshore habitats for rearing during their first summer, but due to their small size, these fish would not be targeted by recreational anglers.
- YOY LCT utilizing nearshore areas would be expected to move laterally along the shoreline, away from recreation-related disturbances (e.g., bed disturbance associated with boat parking), to nearshore areas of the lake that are unaffected.
- Boat noise and disturbance would be temporary in nature.
- Nearshore boating-related propeller entrainment and substrate disturbance effects to LCT are currently believed to be minimal, and would be expected to remain minimal, and not affect population size.
- Current fishing regulations would continue to apply and continue to be evaluated by fish management agencies to maintain recreational fisheries.

- A no-wake zone would be maintained at 600 feet from the water line and speed would continue to be limited to 5 mph in the no-wake zones. This would minimize wake-related disturbances of fish and substrates from increased boating activity.

- Existing AIS detection, control, and eradication efforts for macrophytes and macroinvertebrates would continue.

- New public structures would be equipped with sufficient numbers of trash receptacles to minimize inadvertent disposal of trash in the lake.

Mountain Whitefish

Adult mountain whitefish inhabit deep water areas of the lake, except during spawning migrations to tributary streams and, thus, would not be affected by nearshore boating activity or angling that occurs from shorezone structures. YOY mountain whitefish move into the vegetated nearshore environment of the lake after hatching in tributary streams and rear in nearshore habitats prior to moving into deeper water as they grow larger. Nearshore recreation-related activities under Alternative 1 may affect YOY mountain whitefish, relative to baseline conditions, because YOY occur in the nearshore environment of the lake for rearing. Open water recreation-related activities under Alternative 1 may affect adult and subadult mountain whitefish, because open water boating and open water angling would increase under Alternative 1. Recreation-related effects to mountain whitefish populations would be limited for the same reasons that recreation-related effects to LCT would be limited.

Lahontan Lake Tui Chub

Increased recreation-related activities under Alternative 1 have the potential to affect Lahontan Lake tui chub. Adult Lahontan Lake tui chub spawn in nearshore environments and all life stages of the *pectinifer* subspecies spend time foraging in the nearshore environment. The *obesa* Lahontan Lake tui chub spends most of its life in the pelagic zone of the lake. The *obesa* Lahontan Lake tui chub occurs only in the nearshore environment for spawning and for rearing during their first summer after hatching. Recreation-related effects to Lahontan Lake tui chub populations would be limited for many of the same reasons that effects on LCT and mountain whitefish would be limited. In addition, effects on Lahontan Lake tui chub populations would be limited for the following reasons:

- Adult and subadult *obesa* Lahontan Lake tui chub generally feed in deeper portions of the lake, away from where the increased angling from piers and substrate contact from boating could occur. Thus, adult and subadult Lahontan Lake tui chub feeding would not be affected by nearshore recreational activities (i.e., bed disturbance or boat parking).

- Adult and subadult *obesa* Lahontan Lake tui chub would not be targeted by bait fisherman since bait fishing typically occurs in the nearshore environment.

- Adult and subadult *pectinifer* Lahontan Lake tui chub forage in nearshore areas. Foraging generally occurs at night when recreation-related activities would not coincide with foraging activity.

- Adult Lahontan Lake tui chub spawn in nearshore areas less than 5 feet deep, over sandy bottoms and in stream mouths, primarily during May and June. Spawning generally occurs at night when recreation-related activities would not coincide with spawning activity.

- Because all life stages of Lahontan Lake tui chub would not be expected to use nearshore habitats within marinas, and PAHs from increased boating would be expected to increase mostly in marinas where boat traffic is concentrated, and engines do not run at an efficient level, potential increases in PAHs in marinas would not affect Lahontan Lake tui chub.

- Spawning adult Lahontan Lake tui chub do not build nests, so their eggs are not concentrated into one specific area. Therefore, even during peak boat use days, such as Independence Day or Labor Day, likelihood of a boat crushing numerous eggs when parking on sandy shorelines or entraining large numbers of eggs is low. As such, the anticipated level of increased boating activity (and boat shoreline parking) would not be expected to substantially increase the percent of all eggs spawned in a given year that are lost due to boat parking on sandy shorelines, and thus would not adversely affect annual production of this species.

- Nearshore boating-related propeller entrainment and substrate disturbance effects to Lahontan Lake tui chub are currently believed to be minimal, and would be expected to remain minimal, and not affect population size.

Native Nongame Fish (Minnows, Sculpins, Suckers)

Native nongame fishes include Lahontan speckled dace, Lahontan redside shiner, Paiute sculpin, and Tahoe sucker. Although these species are native to Lake Tahoe, none are considered special-status species. These fish species are part of the nearshore assemblage and spend portions of their life cycle in the nearshore environment, including spawning. Adult native nongame fishes all spawn in the nearshore environment and all but adult Paiute sculpin spend most of their life in the nearshore environment. YOY Paiute sculpin feed in the nearshore environment, but as adults and subadults the species is more often associated with deep water aquatic macrophyte beds. Recreation-related effects to native nongame fishes would be limited for many of the same reasons described above, and for the following reasons:

- Adult and subadult Paiute sculpin generally feed in deeper portions of the lake, outside of the nearshore environment and would not be expected to be affected by increased open water recreational angling because they are not a targeted game species or a species captured by anglers and used as bait.

- Adult Lahontan redside shiners and Lahontan speckled dace spawning typically occurs at night when recreation-related activities would not occur.

- Native nongame fish egg incubation occurs in nearshore areas and incubating eggs could be affected. However, recreation-related disturbance of eggs could potentially occur for a very small percentage of native nongame fish eggs spawned in the lake’s nearshore habitat because the area of potential spawning is large relative to the area of anticipated disturbance from increased recreation and boating.

- Because all life stages of native nongame fish would not be expected to use nearshore habitats within marinas, and PAHs from increased boating would be expected to increase most in marinas where boat traffic is concentrated, and engines do not run at an efficient level, potential increases in PAHs in marinas would not affect native nongame fish.

- Nearshore boating-related propeller entrainment and substrate disturbance effects to native nongame are currently believed to be minimal, and would be expected to remain minimal, and not affect population size.

Coldwater Game Fish

Coldwater game fishes include lake trout, kokanee, brown trout, rainbow trout, and brook trout. Lake trout exclusively inhabit the pelagic, deep water areas of the lake year-round and would not be affected by nearshore boating activity or angling that occurs from shorezone structures. However, increased deep water fishing from boats could affect lake trout.

Kokanee and brook trout inhabit deep water areas of the lake, except during spawning migrations to tributary streams and thus would not be affected by nearshore boating activity or angling that occurs from shorezone structures. Adult rainbow trout and brown trout use the nearshore environment at night for feeding and during their spawning migrations into tributary streams. YOY coldwater game fish move into the vegetated nearshore environment of the lake after hatching in tributary streams and rear in nearshore habitats prior to moving into deeper water as they grow larger. Increased nearshore boating and angling activities under Alternative 1 may affect YOY coldwater game fish, because YOY move into the nearshore environment of the lake for rearing. Based on the studies cited above, the incremental increases in open water recreation-related boating and angling activities under Alternative 1 are not anticipated to result in substantial adverse effects on adult and subadult coldwater game fish. A range of recreation-related effects from boating and angling that could occur to YOY coldwater game fish. However, the effects on YOY coldwater game fish would be limited for many of the same reasons described above, and for the following reasons:

- Lake trout, adult kokanee, and brook trout generally use the colder hypolimnion in the summer so would not be susceptible to entrainment or propeller strikes from open water boating.

- Brown trout and rainbow trout adults generally utilize open water areas but do use the nearshore environment at night for foraging, when temperatures are suitable. Foraging generally occurs at night when nearshore recreation-related activities would not coincide with foraging activity.

- YOY coldwater game fish (except for lake trout) utilize vegetated nearshore habitats for rearing during their first summer, but due to their small size these fish would not be targeted by recreational anglers.

- Nearshore boating-related propeller entrainment and substrate disturbance effects to coldwater game fish are currently believed to be minimal, and would be expected to remain minimal, and not affect population size.

Increased boating and angling under Alternative 1 could have effects to all species evaluated. However, based on life history characteristics, habitat use for the species evaluated, and resource protection measures that would be implemented, substantial adverse effects would not occur to any of the lake's fish populations. Based on the assessment above, Recreational-related impacts under Alternative 1 would not:

- reduce the ability to attain or maintain TRPA threshold standards for LCT, lake habitat, or AIS;
- substantially change the diversity or distribution of any fish species in Lake Tahoe;
- reduce the number or viability of any fish species in Lake Tahoe;
- result in a barrier to any fish species movement in Lake Tahoe; or
- substantially reduce the suitability of habitat for any fish species in Lake Tahoe.

Based on these findings, Alternative 1 would result in a **less-than-significant** impact for all fish species and guilds evaluated.

Alternative 2: Maintain Existing TRPA Shorezone Regulations (No Project)
Under Alternative 2, there is no cap on the number of structures permitted. However, because structure placement is limited by fish habitat designations, the maximum number of new structures are estimated as: 4,871 buoys; 1,897 slips; 476 piers; six boat ramps; two marinas, and 168 private boat lifts. Changes in the number of moorings and access points would result in an estimated annual increase in motorized boating of 53 percent. Compared to baseline conditions this would include approximately 2,600 additional boat trips on a peak day (i.e., summer holiday weekend) and approximately 124,800 additional annual boat trips. Because recreational activities would primarily occur in the summer, impacts would be limited to summer months (May 1 through September 30). Additionally, no new boater education measures would be enacted under Alternative 2.

Recreation-related impacts under Alternative 2 would be similar to those identified under Alternative 1. Under Alternative 2, however, recreation-related impacts would occur more frequently than under Alternative 1 because Alternative 2 includes a greater number of structures and a commensurate increase in boating. However, based on the same life history characteristics and habitat use for the species evaluated under Alternative 1, impacts from Alternative 2 would be **less than significant**.

Alternative 3: Limit New Development
Under Alternative 3, 365 buoys, 5 public piers; 86 private piers; and one new boat ramp would be developed. Like Alternative 1, marina expansion would be allowed if coupled with environmental improvements. Under Alternative 3, annual boating activity would increase by an estimated 4 percent. Compared to baseline conditions this would include roughly 200 additional boat trips on a peak day (i.e., summer holiday weekend) and approximately 8,600 additional annual boat trips.

Recreation-related impacts under Alternative 3 would be similar to those identified under Alternative 1. However, under Alternative 3 recreation-related impacts would occur less frequently than under Alternative 1 because Alternative 3 includes construction of fewer structures and less boat activity. As with Alternative 1, impacts associated with increased boating and recreational fishing associated with Alternative 3 would be minimized because of the resource protection measures included as part of the alternative. Based on the same reasons identified in Alternative 1, Alternative 3 would result in a **less-than-significant** impact.

Alternative 4: Expand Public Access and Reduce Existing Development

Alternative 4 would allow 15 new public piers and no other new shoreline structures. Because this alternative would authorize no new moorings or boat ramps, it would not result in increased boat use. However, recreational angling, and trash and contaminants from use of piers could increase. Increased angling could benefit native fish species by increasing pressure on nonnative warmwater fish species. However, piers could also increase angling pressure on any coldwater game species that occur in the nearshore environment. Increased angling and trash and contaminants from piers could result in a suite of sublethal effects, as well as mortality of individual fish.

Recreation-related impacts under Alternative 4 would be similar to those identified under Alternative 1. However, under Alternative 4 recreation-related impacts would occur less frequently than under Alternative 1 because Alternative 4 involves construction of fewer structures and no new boat activity. As with Alternative 1, impacts associated with increased boating and recreational fishing associated with Alternative 4 would be minimized because of the resource protection measures included as part of the alternative. Based on the same reasons identified in Alternative 1, Alternative 4 would result in a **less-than-significant** impact.

Mitigation Measures

No mitigation is required.

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