Freshwater Fish – Introduction

Freshwater fish species play an important role in the social and economic fabric of Alaska. Many are important for subsistence. Recreational and commercial fishing for many species, such as Arctic char, pike, rainbow trout, Dolly Varden, sheefish, and the 5 species of Pacific salmon, account for millions of dollars in commerce annually in Alaska. However, Alaska's "nongame" fish species—species that are *not* recreationally or commercially harvested—play a crucial role in aquatic ecosystems and, through predation by terrestrial, avian, and marine species, in other ecosystems as well. Some freshwater fish species constitute an important element of the food chain for many other species including species of potential conservation concern, such as loons and beluga whales.

In April 2004, ADF&G convened a diverse group of freshwater fish experts and asked these scientists to develop a short list of species and/or species groups to feature in the CWCS, including specific conservation actions that could be started in the next decade. The group reviewed a complete list of freshwater and anadromous candidate species that excluded species routinely harvested in sport or commercial fisheries in Alaska. By mutual agreement, the group then excluded species (e.g., sturgeon) that occur only incidentally in Alaska. The experts compared the status of the remaining 25 species against 15 criteria; these included the 11 "species selection criteria" listed in Section II(D), plus other criteria the group generated, including whether a species is used by humans, is important prey for another "at-risk" species, or is of demonstrated special scientific importance.

Based on these criteria and the limited time available at the meeting, the group elected to prepare templates on 8 featured species or species groups: lampreys (species group), broad whitefish (*Coregonus nasus)*, Bering cisco (*Coregonus laurettae)*, pygmy whitefish (*Prosopium coulteri)*, Alaska blackfish (*Dallia pectoralis)*, trout-perch (*Percopsis omiscomaycus)*, anadromous smelts (species group), and stickleback (Cook Inlet radiation). Conservation actions designed to protect the fish species and habitats shown on the following templates will likely benefit not only the human users of these species, but also the populations of game fish species inhabiting the same lakes and drainages.

Failure of a species to be selected through this process as a featured species does not mean a species is unimportant or not in need of further study. For example, round whitefish, longnose sucker, slimy sculpin and ninespine stickleback are widely distributed in Alaska and common, while prickly sculpin and coastrange sculpin have a more restricted distribution; all have been virtually unstudied. Lake chub has a restricted distribution in Alaska but populations are contiguous with other North American populations; it is an abundant and important forage species but unstudied in Alaska. The remaining whitefish species are all very important because of human use for subsistence. The USFWS Office of Subsistence Management has recently funded studies on whitefish, but genetic and taxonomic studies, particularly of the humpback whitefish species complex, remain to be addressed.

There are huge data gaps regarding life history, abundance, and trophic structure for all these species. Overall they are poorly understood, especially in terms of Western science. However, the ecological role they perform is undoubtedly very important in aquatic, and for anadromous species, estuarine and marine ecosystems. In June 2005, the ADF&G Sport Fish Division, with partial funding from SWG monies developed an Alaska freshwater fish community and habitat database with interactive mapping capabilities. This database is located at http://www.sf.adfg.state.ak.us/statewide/SF_home.cfm and includes the list of freshwater species found in Alaska, maps indicating where species have been collected or observed, and a link to general biological information on species. These data do not represent exhaustive inventories, but are compilations of existing knowledge from field biologists that are updated periodically as knowledge improves.

Lampreys

A. Species group description

Common names: lampreys (often colloquially/locally referred to as "eels" in Alaska and elsewhere)

Scientific names:

- Pacific lamprey – *Lampetra tridentate* (Richardson 1836)
- western brook lamprey – *Lampetra richardsoni* (Vladykov and Follett 1965)
- river lamprey – *Lampetra ayresii* (Gunther 1870)
- Arctic lamprey – *Lampetra camtschatica* (Tilesius 1811), *(*Mecklenburg et al. 2002)*; Lampetra japonica* (Berg 1948*); Lentheron camtschatica* (Kottelat 1997*)*
- Alaskan brook lamprey – *Lampetra alaskense (*Vladykov and Kott 1978)
- Siberian (brook) lamprey – *Lethenteron kessleri; Lampetra kessleri; Lampetra japonica kessleri* (Anikin 1905)

B. Distribution and abundance

Range:

Global Range Comments: Poorly known, particularly in and across northerly areas/countries

- Pacific lamprey: Eastern Pacific drainages from very northern Mexico to Alaska, across the Aleutian Island chain into the western Pacific and north to Hokkaido, Japan
- western brook lamprey: Eastern Pacific from the Sacramento River in California to just north of Juneau, Alaska
- river lamprey: Eastern Pacific from California to southeastern Alaska
- Arctic lamprey: Bering Sea and Arctic drainages to Anderson River (Canada) and south to Japan/Korea
- Alaskan brook lamprey: Range is considered the same as for Arctic lamprey, but perhaps most often with a more inland range; this species in particular is not consistently recognized or understood.

State Range Comments: Distributions and relationships very poorly known in Alaska

- Pacific lamprey: Pacific drainages up to at least the Bering Sea with records into lower Yukon/Kuskokwim
- western brook lamprey: southern Southeast Alaska north to approximately 20 mi north of Juneau, Alaska
- river lamprey: Southeastern Alaska north to approximately Tee Harbor, Alaska

- Arctic lamprey: Bering Sea and Arctic drainages, and possibly into northern north Pacific river basins
- Alaskan brook lamprey: Range considered same as for Arctic lamprey, but perhaps most often with a more inland range

Abundance:

Global abundance comments: Serious conservation concern throughout ranges

State abundance comments: Unknown, but often found in Alaska with some local abundance

Trends:

Global trends: Declining across ranges outside of Alaska in North America and globally

State trends: Unknown

References: Beamish and Northcote 1989; Klamath-Siskiyou Wildlands Center (and other petitioners) 2003; Larson and Belchik 1998; Maitland 2003; Mecklenburg et al. 2002; Weeks 1991

C. Problems, issues, or concerns for species group

There is a paucity of information about lamprey species in Alaska and their habitats**.**

- We lack much basic information on such topics as abundance, age structure, diet, trophic ecology, homing/migration, species identification, range, instream flow/water volume and habitat needs (Beamish and Levings 1991; Beamish and Youson 1987; Vladykov and Follett 1965; Young et al. 1990).
- The systematics of Alaska's diverse lamprey species is difficult to determine.
    a) Lamprey species can be hard to identify, especially in juvenile stages (McPhail and Carveth 1994).
    b) Systematics of lamprey is very incomplete and poorly understood; needs research and inventory.
    c) Lampreys are classically thought of as occurring in "species pairs" or "satellite pairs" (Mecklenburg et. al. 2002) with one species parasitic (and anadromous) and its "congener species" nonparasitic derivative (and a freshwater resident) (Beamish 1987, Beamish and Neville 1992; Vladykov and Kott 1979; Vladykov 1985). Examples:
        - river lamprey (parasitic) and western brook lamprey (nonparasitic) (Mecklenburg et. al. 2002) (Also see "distribution" info)
        - Arctic lamprey (parasitic) and Alaskan brook lamprey (nonparasitic)
    d) Populations that are isolated or with unusual life histories are described as distinct species elsewhere in the Pacific (Docker et al. 1999; Haas 1998; Klamath-Siskiyou et al. 2003; Kostow 2002).

   e) Lamprey diversity in Alaska is poorly documented and understood (McPhail and Lindsey 1970; Morrow 1980); although lampreys are usually listed as fish, there is currently some debate about it; their overall group is superclass Agnatha, class Cephalaspidormphi, order Petromyzontiformes.
   f) The taxonomic status of lamprey species is unresolved due to differing viewpoints on significance of life history types, and the complexities of relationships between species (Mecklenburg et al. 2002).

- Alaska likely has many populations with possibly rare or unique life-history characteristics.
   a) Confusing parasitic and non-parasitic "paired species" relationships exist due to unresolved genetic analyses, and degenerative changes with maturation resulting in inconsistent taxonomic identification (McPhail and Lindsey 1970, Mecklenburg et. al. 2002; Morrow 1980).
   b) Non-parasitic freshwater forms are believed to have evolved from parasitic anadromous forms, but unusual "intermediates," such as freshwater parasitic forms, exist.
   c) Geological isolates are not uncommon and are found in Alaska (Hastings and Haas 2002).
- Serious lamprey conservation/management issues exist elsewhere; extent and nature of issues to be expected in Alaska are unknown but may include:
   a) Lampreys are described as having serious conservation concern throughout most of their natural range (Renaud 1997).
   b) Lampreys (particularly Pacific lamprey) have been petitioned for listing as endangered species in the contiguous United States under the U.S. Endangered Species Act (Klamath-Siskiyou et al. 2003).
   c) There has been a collapse of Native subsistence and commercial fisheries outside of Alaska (e.g., Close et al. 2002).
   d) Lampreys are of considerable cultural and food importance for Native Americans (Close et al. 2002).
   e) Similar conservation/management/extinction issues are recognized elsewhere in the range (Beamish and Northcote 1992, Frissel 1993, Haas 1998, Kostow 2002).
   f) Lamprey are taken as a food fish in the lower Kuskokwim and Yukon Rivers and possibly elsewhere in Alaska.
   g) Subsistence harvest locations, levels, species, etc., are poorly documented or unknown.
   h) An emerging commercial fishery is possible in at least some regions, with unknown impacts.

i) Lampreys are possibly an important forage fish for species of conservation concern.

j) Anadromous lampreys appear to have similar life history and habitat needs to salmonids; it is unknown whether factors causing decline of salmon stocks also cause declines in lamprey populations within the same drainages.

D. Location and condition of key or important habitat areas

Key or important habitat areas are largely undescribed and unknown in Alaska; lampreys may occur in other habitat types than listed here.

While it is believed that adult lampreys have similar habitat/spawning needs as salmon (e.g., Vadas 2000), a 2003 Bristol Bay inventory found adult Alaskan brook lamprey in locations not occupied by salmon. Alaskan brook lamprey appear to have greater tolerance for streams with low gradient, fine substrate, and low dissolved oxygen than do salmon (M. Wiedmer, pers. comm.).

Rearing habitat for all juvenile lampreys (ammocoetes) is different from that used by the adults. Juvenile lampreys prefer slow-flow freshwater areas/sloughs with silt/mud bottoms (Sugiyama and Goto 2002). In the 2003 Bristol Bay inventory mentioned above, juvenile lamprey were often found in headwater habitats, if suitable habitat (soft bottoms) was available (M. Wiedmer, pers. comm.).

Resident nonparasitic lampreys use freshwater habitat for their entire life cycle; their ammocoetes only mature into adults for reproduction. Resident parasitic lampreys mature into adults, and feed as adults, in fresh water; some may spawn in lakes.

E. Concerns associated with key habitats

Lampreys seem to have similar habitat requirements as salmon (e.g., Vadas 2000); concerns for habitat destruction and degradation include effects originating instream (channelization, instream flow/water volume alteration, temperature, impoundment, passage, sedimentation) and those influences originating from outside the stream (pollution, riparian zone loss, ocean [or lake] conditions, and climate change).

F. Goal: Conserve and manage populations of Alaska lamprey species throughout their natural range to ensure sustainable use of these resources.

G. Conservation objectives and actions

Objective: Maintain species distribution, population abundance, and life history variability indicative of viable lamprey species complexes throughout their native habitats in Alaska.

Target: Identify the distribution of lamprey species in Alaska.

Measure: Document lamprey distribution within Alaska as determined by literature review and surveys for ammocoetes in potential habitat.

Target: Lamprey ammocoetes are present in at least 90% of identified index areas.

Measure: Presence of lamprey ammocoetes in index areas (to be determined).

Target: Density of ammocoetes is within natural variability in at least 90% of selected lamprey rearing areas.

Measure: Density of ammocoetes annually over a 10-year period in selected index areas.

Issue 1: Identification of species is difficult.

Conservation action: Develop criteria and an approach for identification of ammocoetes and adult lampreys.

Issue 2: Unknown distribution of lamprey.

Conservation actions:

a) Document the freshwater distribution of the various species of lampreys in Alaska by sampling for ammocoetes and adults in a representative selection of drainages.

b) Develop sampling protocols and implement sampling schedule across geographic range in Alaska.

c) Identify representative index areas.

d) Identify and describe the habitat types or categories used by various species and their life forms (e.g., as used in ADF&G's freshwater fish inventory database); develop and conduct sampling in rearing areas for ammocoetes to document distribution.

e) Develop sampling techniques and document the migration and movement patterns of different species and life stages.

f) Develop a network of biologists/organizations to establish unified protocols, share data, leverage sampling efforts, and provide voucher specimens to museums (UAF, etc.). AFS-Alaska Chapter might be a venue for organizing and consolidating information.

Issue 3: Habitat alteration, sufficient instream flow/water volume, fish passage, and sedimentation are potential concerns.

Conservation actions:

a) Determine instream flow/water volume needs and habitat requirements for all life history phases of lampreys.

b) Consider lamprey species when there are issues of fish passage and habitat alteration (e.g., water diversions, dams, timber harvest, mining, sedimentation).

c) Develop a coordinated effort among government and nongovernment agencies to coalesce and exchange information on the habitat and instream flow/water volume needs of lampreys.

Issue 4: Lampreys are taken as a food fish (e.g., lower Yukon/Kuskokwim, possibly other areas); harvest levels are not monitored.

Conservation actions:

a) Obtain local information and knowledge on local lamprey distribution, relative abundance, and harvest.

b) Develop sampling protocol to monitor locations, timing, magnitude, and catch per unit effort (cpue) of harvest.

c) Involve communities in monitoring, and share information.

d) Train local communities to monitor abundance and harvest effort.

Issue 5: Emerging commercial fishery for lamprey on the Yukon River with a lack of assessment.

Conservation action: Document the number and magnitude of the commercial fisheries for lampreys that are occurring in the state; collect biological samples of lampreys (e.g., size, sex ratio, and if possible, species, age structure).

Issue 6: Lampreys may be important forage fish for various freshwater and marine predators, some of which have been identified in this Strategy as of conservation concern.

Conservation action: Determine the trophic ecology of lampreys.

H. Plan and time frames for monitoring species and their habitats

Promote coordination with state agencies, federal agencies, universities, industry, Native entities, and NGOs to conduct monitoring every year for 10 years to establish the target indices. Wherever possible, make use of any existing fisheries to collect data and information.

The University of Alaska Fairbanks, Museum of the North is interested in coordinating and undertaking inventory and research in general for nongame (and game) fish in Alaska. The Museum of the North would provide expertise, training, and resources for proper collections, as well as storage in perpetuity and curation. ADF&G's ongoing statewide fish inventory program should coordinate with the Museum of the North to ensure proper preparation and submittal of voucher specimens for curation.

I. Recommended time frame for reviewing species status and trends

Review within 5 years, and then at such frequency in the future to ensure progress.

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Anadromous Smelts

A. Species group description

Common name(s): anadromous smelts (i.e., longfin smelt, eulachon, rainbow smelt)

Scientific names: *Spirinchus thaleichthys, Thaleichthys pacificus, Osmerus mordax*

B. Distribution and abundance

Range:

Global range comments: Full extent unknown, but populations of some species occur in British Columbia, northwestern and northeastern United States (with introductions in Great Lakes areas), and northwestern Pacific Ocean and Bering Sea (Korea, Japan, Russia)

<u>State range comments</u>: Longfin smelt: Shelikof Strait, southwestern Gulf of Alaska, through Southeast. Rainbow smelt: entire coast of Alaska, but less common along Gulf of Alaska. Eulachon: Southwestern Alaska, Aleutians, Southcentral Alaska through Southeast Alaska.

Abundance:

<u>Global abundance comments</u>: Unknown

<u>State abundance comments</u>: Unknown

Trends:

<u>Global trends</u>: Declining trends for anadromous smelt species across parts of their range

<u>State trends</u>: Unknown

References: McPhail and Lindsey 1970; Mecklenburg et al. 2002; Morrow 1980

C. Problems, issues, or concerns for species group

- Anadromous smelt species are an important forage fish for various marine predators, some of which have been identified in this Strategy as of conservation concern (e.g., Cook Inlet beluga whales). (See the Marine Fish template called "Forage Fish Occurring in Intertidal/Shallow Subtidal Areas.")
- Alaskan populations of anadromous smelt species are poorly documented.
- There is a lack of information on these species, including life history, abundance, trophic ecology and instream flow/water volume needs.
- They are taken as a human food fish throughout their range.
- Threats exist to freshwater and estuarine habitat and fish passage.
- There is a high interannual variability in populations suggested by saltwater trawl surveys.

D. Location and condition of key or important habitat areas

For all 3 species: Lower reaches of streams and rivers and associated estuaries (e.g., Susitna River); also, eulachon are known to ascend $\geq$ 100 km up the Susitna (Yentna) system and rainbow smelt to enter Lower Ugashik Lake, likely spawning in tributaries to the lake (M. Wiedmer, pers. comm.). Significant eulachon runs also occur in the Kenai, Twenty-mile, and Eyak Rivers.

- On the North Slope, rearing also occurs in connected lakes in river deltas
- Habitat condition overall is thought to be very good to pristine
- Marine habitat and ecological conditions are unknown

E. Concerns associated with key habitats

- Potential impacts of water diversion or impoundment on movements, spawning and rearing habitats, and survival
- Nearshore chronic and acute pollution (such as oil spills, wastewater effluent)
- Broad-scale climate shifts affecting marine ecological conditions

F. Goal: Conserve and manage populations of Alaska anadromous smelt species throughout their natural range to ensure sustainable use of these resources.

G. Conservation objectives and actions

<u>Objective</u>: Maintain species distribution and population abundance within natural variation throughout their distributions in Alaska.

Target: Identify the distribution of anadromous smelt species in Alaska.
Measure: Anadromous smelt distribution within Alaska as determined by literature review and surveys at river mouths to the limits of upstream spawning habitat.

Target: Anadromous smelt species are within their natural variability of abundance in at least 90% of identified index areas.
Measure: Abundance of anadromous smelt species annually over a 10-year period in identified index areas.

<u>**Issue 1:** Anadromous smelt species are important prey for predators of conservation concern (e.g., beluga whales, loons).</u>

Conservation action: Work with marine scientists (e.g., marine mammal biologists, waterbird and seabird biologists) and Native harvesters to document the significance of anadromous smelt species in the diet of target species. Determine the trophic ecology of anadromous smelt species.

<u>**Issue 2**: Lack of information on this species: life history (e.g., iteroparity vs. semelparity), population structure, migration patterns, distribution, trophic ecology, and habitat needs/use.</u>

Conservation actions:
a) Develop sampling and indexing protocols and implement sampling schedule across geographic range.
b) Identify representative index areas.
c) Identify the habitat types or categories used by anadromous smelts (e.g., as used in ADF&G’s freshwater fish inventory database).
d) Develop sampling techniques and document the migration and movement patterns of different species and life stages.
e) Map current distribution and other similar habitats for future investigation.
f) Develop a network of biologists/organizations to establish unified protocols, share data, leverage sampling efforts, and provide voucher specimens to museums (UAF, etc.). AFS-Alaska Chapter might be a venue for organizing and consolidating information.

<u>**Issue 3:** Habitat alteration, sufficient instream flow/water volume, fish passage, and water quality are potential concerns.</u>

Conservation actions:

a) Determine instream flow/water volume needs and habitat requirements for all life history phases of smelts.
b) Consider these smelt species when there are issues of fish passage and habitat alteration (e.g., water diversions, dams, timber harvest, mining, sedimentation).
c) Develop a coordinated effort among government and nongovernment agencies to coalesce and exchange information on the habitat and instream flow/water volume needs of these smelts.

Issue 4: Anadromous smelt species are taken as a food fish; harvest levels are not monitored for all species in all locations.

Conservation actions:

a) Obtain local information and knowledge on local anadromous smelt distribution, relative abundance, and harvest.
b) Develop sampling protocol to monitor locations, timing, magnitude, and level of harvest.
c) Collect biological samples (e.g., size, sex ratio and species, age structure).
d) Involve communities in monitoring, and share information.
e) Train local communities to monitor abundance and harvest effort.

H. Plan and time frames for monitoring species and their habitats

Promote coordination with state agencies, federal agencies, universities, Native entities, and NGOs to conduct monitoring every year for 10 years to establish the target indices. Possibly involve AKNHP to administer the RFP process for monitoring.

I. Recommended time frame for reviewing species status and trends.

Review at 5 years.

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Bering Cisco

A. Species description

Common name: Bering cisco
Scientific name: *Coregonus laurettae*

B. Distribution and abundance

Spawning populations are known to be in the Yukon, Kuskokwim, and Susitna river drainages. All Bering ciscos are considered anadromous, and no subadult fish have been documented in fresh water. In the Yukon River, spawning migrations extend at least 1700 km upstream, into the upper region of the Yukon Flats; the farthest upstream record is from Dawson City in Yukon Territory, over 2000 km from the sea. Marine distribution in the Bering Sea extends from Bristol Bay to Kotzebue Sound, and some individuals have been identified across the Beaufort Sea coast to Prudhoe Bay. Bering cisco have been reported from nearshore waters of the Chukotsk Peninsula, north of the Bering Straight, but these were probably migrants from Alaska, as no spawning populations have been reported from Asia. The marine distribution of the Susitna River population is unknown, but presumably they range throughout Cook Inlet waters and perhaps even farther. Abundance of the 3 identified Bering cisco populations are unknown, but Bering cisco are not rare where they are found.

Range:
Global range comments: Spawning populations known to be in Yukon, Kuskokwim, and Susitna Rivers; marine distribution includes Bering, Chukchi, and Beaufort Seas, and Cook Inlet
State range comments: same as previous

Abundance:
Global abundance comments: Bering cisco essentially endemic to Alaska
State abundance comments: Unknown

Trends:
Global trends: Unknown
State trends: Unknown

References: ADF&G 1983; Alt 1973; Bickham et al. 1992; Brown 2000; Chereshnev 1985; DeGraaf 1981

C. Problems, issues, or concerns for species

- Lack of information on spawning area locations in the Kuskokwim and Yukon Rivers; spawning populations are not known elsewhere in Alaska
- In freshwater systems, fisheries bycatch of returning spawners in the salmon fishery in summer/fall (Yukon/Kuskokwim Rivers) in the fish wheels
- Localized human harvest (very abundant in river and coastal regions: potential for fishery development though not currently exploited)

- Spawning areas very confined/localized and thus vulnerable to localized habitat disturbance (true for Susitna River population; situation unknown for Kuskokwim and Yukon Rivers)
- Major ecological changes in the Bering Sea could impact population levels

D. Location and condition of key or important habitat areas

- Only known to spawn in 3 large river systems in Alaska—Yukon, Kuskokwim, Susitna
- Freshwater phase(s): egg development, emergence and spawning; thought to have highly confined/localized spawning areas; spring increase in flow triggers egg hatch in early spring and subsequent flush of larvae to salt water
- Marine phase: coastal/nearshore environment from Bristol Bay to Pt. Barrow, and Cook Inlet; also present (but rare) in nearshore Beaufort Sea at least as far east as Prudhoe Bay region. Males live in coastal environment 5–7 years, females 6–9 years

<u>Condition of coastal areas in Alaska salt water</u>: very good to pristine
<u>Condition of large freshwater river systems</u>: very good to pristine

E. Concerns associated with key each habitats

Water diversion or impoundment could impact movements toward spawning and other habitats (low probability).

F. Goal: Conserve and manage populations of Bering cisco throughout their natural range to ensure sustainable use of these resources.

G. Conservation objectives and actions

<u>Objective</u>: Maintain current spawning distribution and abundance within natural variation of Bering cisco populations in Alaska.

Target: Current level of abundance within natural variation.
Measure: Use cpue as determined by random fish wheel or gillnet sampling or other means on the Yukon, Kuskokwim, and Susitna Rivers as abundance index.

Target: 100% of known spawning locations/areas identified.
Measure: Presence of spawning Bering cisco on known spawning locations in spawning season (September/October).

<u>**Issue 1**: Lack of information on spawning area locations in the Kuskokwim, and Yukon Rivers.</u>

Conservation action: Document the spawning distribution, e.g., by using radio telemetry.

<u>**Issue 2:** Localized human harvest as bycatch in salmon fisheries and no monitoring of the catch is occurring; potential for fishery development, though not currently exploited.</u>

Conservation actions:

a) Establish a system for estimating total harvest by randomly sampling fish wheel harvest on the Yukon and Kuskokwim Rivers; use cpue as an index of abundance for Bering cisco.
b) Estimate the size of Bering cisco stocks in Alaska using mark-recapture methods to evaluate the impact of bycatch and potential development of commercial fisheries.
c) Obtain local information and knowledge on Bering cisco distribution, relative abundance, age structure of the population, and harvest.
d) Develop sampling protocol to monitor locations, timing, magnitude and cpue of harvest.
e) Involve communities by training local individuals to monitor abundance and harvest, and by sharing information with affected villages.

Issue 3: Bering cisco are an important forage fish for various freshwater and marine predators, some of which have been identified in this Strategy as of conservation concern (e.g., loons).

Conservation action: Determine the trophic ecology of Bering cisco.

Issue 4: Habitat alteration, sufficient instream flow/water volume, fish passage, and water quality are potential concerns.

Conservation actions:

a) Determine instream flow/water volume needs and habitat requirements for all life history phases of Bering ciscos.
b) Consider Bering cisco when there are issues of fish passage and habitat alteration (e.g., water diversions, dams, timber harvest, mining, sedimentation).
c) Develop a coordinated effort among government and nongovernment agencies to coalesce and exchange information on the habitat and instream flow needs of Bering ciscos.

H. Plan and time frames for monitoring species and their habitats

State and federal agencies, universities, industry, Native entities, and NGOs should coordinate to conduct monitoring every year for 10 years to establish the target indices.

I. Recommended time frame for reviewing species status and trends

Review at 5 years.

J. Bibliography

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Chereshnev, I.A. 1985. The first record of the Bering cisco, *Coregonus laurettae*, from the USSR. J. Ichthyol. 24: 88–95.

DeGraaf, D.A. 1981. First Canadian record of Bering cisco (*Coregonus laurettae*) from the Yukon River at Dawson, Yukon Territory. Can. Field-Nat. 95(3):365.

Broad Whitefish

A. Species description

Common name: broad whitefish
Scientific name: *Coregonus nasus*

B. Distribution and abundance

Broad whitefish are widely distributed in Alaska fresh water from the Kuskokwim River drainage north to the Beaufort Sea drainages of the North Slope. Diadromous individuals frequent brackish water estuaries throughout their range, but they are not thought to venture far out to sea. Freshwater resident individuals are present in some systems. Broad whitefish are also widely distributed along the northern coasts of Canada and Russia. In Alaska, few spawning areas have been identified. Known spawning areas are in the lower reaches of large rivers, but upstream from the influence of marine water. In northern Alaska, full maturity is reached by age 12. This species uses lakes connected to river systems as major feeding areas, sometimes remaining in lakes until maturity. Abundances of broad whitefish populations are unknown, but broad whitefish are generally not rare where they are found.

Range:

Global range comments: Northern regions of Asia and North America
State range comments: Widely distributed in brackish and fresh water from the Kuskokwim River drainage north and east to the Beaufort Sea coastal region and the Canadian border

Abundance:

Global abundance comments: Unknown
State abundance comments: Unknown

Trends:
<u>Global trends</u>: Unknown
<u>State trends</u>: Unknown

References: Alt 1976; Bendock and Burr 1984, 1985; Berg 1948; Bond and Erickson 1985; Fechhelm et al. 1995a, 1995b; Kline et al. 1998; McPhail and Lindsey 1970; Mecklenburg et al. 2002; Morrow 1980; Reist and Bond 1988; Tallman and Reist 1997

C. Problems, issues, or concerns for species

- Spawning areas have not been located in many systems.
- Instream flow/water volume needs for broad whitefish are unknown.
- In freshwater systems, a limited amount of fisheries bycatch of spawners occurs in the salmon fisheries in summer and fall (Yukon River particularly); no monitoring of bycatch is occurring and population effects, if any, of bycatch are unknown.
- Localized human harvest (abundant in river and coastal regions, actively sought in food fisheries; a preferred fish for subsistence users along the Arctic Coastal Plain and an important fresh food source during the spring and fall in the Lower Kuskokwim and lower Yukon Rivers); no monitoring of the catch or bycatch is occurring.
- Major ecological changes in marine waters could impact population levels.

D. Location and condition of key or important habitat areas

- Spawning, egg development, and emergence are thought to occur in localized areas; spring increase in flow triggers egg hatch in early spring with subsequent larvae flush to lower drainage habitats and to estuaries.
- Freshwater feeding occurs in widely dispersed lentic and lotic habitats.
- Coastal environments and lakes connected to rivers or coastal regions are utilized throughout the species' range.
- Overwintering in Beaufort Sea drainages in Alaska occurs in deep pools in lower reaches; elsewhere in Alaska, overwintering habitats are poorly understood.
- Summer feeding in nearshore waters of the Beaufort Sea in/near deltas of larger rivers.

<u>Condition of saltwater coastal areas in Alaska</u>: very good to pristine
<u>Condition of large freshwater river systems</u>: very good to pristine

E. Concerns associated with each habitat

- Instream flow/water volume alteration, water diversion, or impoundment could impact movements toward spawning and other habitats.
- Mining in spawning habitats could impact entire populations.
- Drier climatic trends, an increase of beavers noted through local traditional knowledge, and reduced or altered instream flows/water volume in Interior Alaska may cause reduced access to off-channel feeding habitats.

F. Goal: Conserve and manage broad whitefish populations throughout their natural range to ensure sustainable use of these resources.

G. Conservation objectives and actions

Objective: Maintain current spawning distribution and abundance within natural variation of broad whitefish populations in Alaska

Target: Current level of abundance within natural variation

Measure: Use cpue and age distribution as determined by random fish wheel sampling on the Yukon River, fish wheel or gillnet sampling on the Kuskokwim River, and standardized net sampling in a selection of other drainages as abundance indices

Target: 100% documentation of drainages known to support spawning populations

Measure: Number of drainages surveyed and mapped for presence of broad whitefish spawners in known or likely spawning drainages during late fall season (September/October)

Issue 1: Lack of information on spawning area locations throughout the state

Conservation action: Document the spawning distribution using radiotelemetry.

Issue 2: Localized human harvest and bycatch in salmon fisheries is large in places; no monitoring of the catch or bycatch is occurring; commercial harvest has occurred in the past; potential exists for additional commercial fishery development in some locations.

Conservation actions:

a) Establish a system for estimating total harvest of select populations by randomly sampling regional harvests; use cpue and age distribution as an index of abundance for monitoring large changes.
b) Estimate the size of certain broad whitefish stocks in Alaska using mark-recapture methods to evaluate the impact of bycatch and potential development of commercial fisheries.
c) Obtain local information and knowledge on broad whitefish distribution, relative abundance, age structure of the population, and harvest.
d) Develop sampling protocol to monitor locations, timing, magnitude, and cpue of harvest.
e) Involve communities by training local individuals to monitor abundance and harvest, and by sharing information with affected villages

Issue 3: Habitat alteration, sufficient instream flow/water volume, fish passage, and water quality are potential concerns.

Conservation actions:

a) Determine instream flow/water volume needs and habitat requirements for all life history phases of broad whitefish.

b) Consider broad whitefish when there are issues of fish passage and habitat alteration (e.g., water diversions, dams, timber harvest, mining, sedimentation).
c) Develop a coordinated effort among government and nongovernment agencies to coalesce and exchange information on the habitat and instream flow/water volume needs of broad whitefish.

H. Plan and time frames for monitoring species and their habitats

State and federal agencies, universities, industry, Native entities, and NGOs should coordinate to conduct monitoring every year for 10 years to establish the target indices.

I. Recommended time frame for reviewing species status and trends

Review at 5 years.

J. Bibliography

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Bond, W.A. and R.N. Erickson. 1985. Life history studies of anadromous coregonid fishes in two freshwater lake systems on the Tuktoyaktuk Peninsula, Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Sciences 1336.

Fechhelm, R.G. W.B. Griffiths, W.J. Wilson, B.J. Gallaway, and J.D. Bryan. 1995. Intra- and interseasonal changes in the relative condition and proximate body composition of broad whitefish from the Prudhoe Bay region of Alaska. Trans Am Fish Soc 124:508–519.

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Morris, W.A. and E.H. Follmann. 1998. Seasonal movements of broad whitefish (*Coregonus nasus*) in the freshwater systems of the Prudhoe Bay Oil Field: annual report 1997 field season. ADF&G, Habitat and Restoration Division. Fairbanks. 31pp.

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Pygmy Whitefish

A. Species description

Common name: pygmy whitefish
Scientific name: *Prosopium coulteri*

The pygmy whitefish is a small whitefish in which parr marks persist in all but the largest adults. It inhabits deep habitats of large postglacial lakes and has a disjunct distribution in North America and in a small area of Russia.

B. Distribution and abundance

Range:

Global range comments: Only known from North America and 3 locations in arctic Russia; disjunct range (Lake Superior and northwestern North America); generally in large postglacial lakes

State range comments: Only known from some large postglacial lakes: Alaska Peninsula/Bristol Bay (Chignik, Becharof, Ugashik, Brooks, Naknek, and Aleknagik Lakes); Copper River drainage (Tonsina, Tazlina, and Klutina Lakes); Lake George in the Cook Inlet watershed (M. Wiedmer, pers. comm.)

Abundance:
Global abundance comments: Unknown, but locally abundant in some areas
State abundance comments: Locally abundant, but not in all locations

Trends:
Global trends: Unknown, likely stable
State trends: Unknown, likely stable

References: McPhail and Lindsey 1970; Morrow 1980; Reshetnikov 2003; Scott and Crossman 1974

C. Problems, issues, or concerns for species

- Incomplete information on this species including life history, abundance, and trophic ecology
- Alaskan populations poorly documented, may occur in other lakes
- Species pairs are rare; need to protect the 2 known species pairs (giant and normal pygmy whitefish) and any others discovered. (Taylor 1999)

D. Location and condition of key or important habitat areas

Deep areas of large postglacial lakes.

E. Concerns associated with key habitats

None that are known.

F. Goal: Conserve and manage pygmy whitefish populations throughout their natural range to ensure sustainable use of these resources.

G. Conservation objectives and actions

Objective: Maintain abundance, size, and age structure within natural variation throughout its native distribution in Alaska.

Target: Fully documented distribution of pygmy whitefish in Alaska.
Measure: Maps of distribution within Alaska as determined by literature review (see bibliography) and surveys in potential native habitat (e.g., prioritized locations would be other large [deep] glacial lakes).
Target: Identify and obtain size and age structure indices of pygmy whitefish populations in Alaska.
Measure: Size and age structure of pygmy whitefish populations in index areas to be determined.
Target: Sampling for, and presence of, reproducing populations noted in all known localities.
Measure: Presence and sexual maturity as determined by surveys
Target: Sampling for, and occurrence noted, in all other potential habitats used by

pygmy whitefish in Alaska.

Measure: Occurrence noted in habitat(s) other than large (deep) glacial lakes.

Issue 1: Species pairs are rare; need to conserve the 2 known species pairs and any others discovered.

Conservation action: Prevent the introduction of nonindigenous species into habitats with species pairs.

Issue 2: Distribution of pygmy whitefish in Alaska may not be completely documented.

Conservation actions:

a) Map current distribution and survey other similar habitats.
b) Develop a network of biologists/organizations to establish unified protocols, share data, leverage sampling efforts, and provide voucher specimens to museums (UAF, etc.). AFS-Alaska Chapter might be a venue for organizing and consolidating information.
c) Obtain local information and knowledge on pygmy whitefish.

H. Plan and time frames for monitoring species and their habitats

Promote coordination with other state agencies, federal agencies, universities, industry, Native entities, and NGOs to conduct monitoring every 5 years to confirm occurrence and relative abundance.

I. Recommended time frame for reviewing species status and trends

Review at 10 years.

J. Bibliography

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board of Canada, Bulletin 173, Ottawa, Canada.

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Morrow, J.E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Co., Anchorage, Alaska.

Reshnetnikov, Y.S. 2003. Atlas of Russian freshwater fish. Vol. 1, Nauka. Moscow.

Scott, W.B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Bulletin 184. Ottawa, Canada.

Taylor, E. B. 1999. Species pairs in north temperate freshwater fishes: Evolution, taxonomy and conservation. Reviews in Fish Biology and Fisheries 9: 299–324, Kluwer Academic Publishers, The Netherlands.

Trout-perch

A. Species description

Common name: trout-perch
Scientific name: *Percopsis omiscomaycus*

The trout-perch is the only percopsid found in Alaska, and it has a very limited distribution. This species likely invaded the Yukon River relatively recently via the Peel and Porcupine Rivers.

B. Distribution and abundance

Range:
Global range comments: Across most of North America from Maryland northward to Hudson Bay, west through Tennessee and the Mississippi drainage, through the prairie provinces northward. The Mackenzie drainage, upper Porcupine and mainstem Yukon River.
State range comments: Mainstem Yukon River from Tatonduk and Kandik River downstream to the Yukon Delta (only reported from mainstem Yukon River).

Abundance:
Global abundance comments: Relatively abundant within its range in Canada and Lower 48 states.
State abundance comments: Not abundant; only captured intermittently.

Trends:
Global trends: Unknown
State trends: Unknown

References: Mecklenburg et al. 2002; McPhail and Lindsey 1970; Morrow 1980; Reshetnikov 2003; Scott and Crossman 1974

C. Problems, issues, or concerns for species

Unknown, but may be positively affected by climate change and warming temperatures since this species thrives in milder climates.

D. Location and condition of key or important habitat areas

Key habitats in Alaska are slow-moving portions of the mainstem Yukon River.

E. Concerns associated with key habitats

None that are known; however, specific habitat requirements are unknown. Water diversion or impoundment and pollution are potential threats.

F. Goal: Conserve and manage Alaskan trout-perch populations throughout their natural range to ensure sustainable use of these resources.

G. Conservation objectives and actions

Objective: Maintain abundance, size, and age structure throughout its native distribution in Alaska.

Target: Identify the native distribution of trout-perch in Alaska.
Measure: Native distribution within Alaska as determined by literature review and surveys in potential native habitat (e.g., Yukon River mainstem and tributaries, near margins of previously documented distributions).

Target: Identify and obtain size and age structure indices indicative of native trout-perch populations in Alaska in index areas.
Measure: Size and age structure of native trout-perch populations in index areas of Alaska to be determined.

Target: Abundance within the natural variability of known populations.
Measure: Native abundance estimates (relative or absolute as determined by cpue or mark-recapture) in Alaska within the bounds of 10-year cycles as determined by literature review and surveys in index areas to be determined.

Issue: Lack of information on this species: life history, population structure, migration patterns, distribution, trophic ecology, and habitat and instream flow/water volume needs.

Conservation actions:
a) Develop sampling protocols and implement sampling schedule across geographic range of trout-perch populations in Alaska.
b) Identify representative index areas.
c) Identify the habitats used by trout-perch (.e.g., as used in ADF&G's freshwater fish inventory database).
d) Map current distribution and habitats for future investigation.
e) Develop a network of biologists/organizations to establish unified protocols, share data, leverage sampling efforts, and provide voucher specimens to museums (UAF, etc.). AFS-Alaska Chapter might be a venue for organizing and consolidating information.
f) Obtain local information and knowledge on local trout-perch distribution and relative abundance.

H. Plan and time frames for monitoring species and their habitats

State and federal agencies, universities, industry, Native entities, and NGOs should coordinate to conduct monitoring every 2 years for 10 years to establish the target abundance index.

I. Recommended time frame for reviewing species status and trends

Review at 5 years.

J. Bibliography

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board of Canada, Bulletin 173, Ottawa, Canada.

Mecklenburg, C.W., T.A. Mecklenburg and L.K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD.

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Morrow, J.E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Co., Anchorage, AK.

Reshetnikov, Y.S. 2003. Atlas of Russian freshwater fish. Vol. 1, Nauka. Moscow.

Alaska Blackfish

A. Species description

Common name: Alaska blackfish
Scientific name: *Dallia pectoralis*

Alaska blackfish is endemic to Beringia. Blackfish populations are also known from Chukotsk Peninsula in the far east of Russia. Alaska blackfish are known for their hardiness and their ability to survive low oxygen levels and partial freezing. They are the only Umbrid (mudminnow) in Alaska.

B. Distribution and abundance

Range:
<u>Global range comments</u>: Alaska and eastern Chukotka
<u>State range comments</u>: Naturally from Colville River delta to Chignik on the Alaska Peninsula, mostly in lowland waters; also on St. Lawrence Island and Nunivak Island; introduced on the Pribilof Islands and to upper Cook Inlet near Anchorage

Abundance:
<u>Global abundance comments</u>: Relatively abundant within its restricted range in Eastern Chukotka
<u>State abundance comments</u>: Abundant in lowland lakes and interconnected waterways, especially in Yukon-Kuskokwim Delta area

Trends:
<u>Global trends</u>: Unknown
<u>State trends</u>: Unknown

References: Berg 1962; Everman and Goldsborough 1907; McPhail and Lindsey 1970; Morrow 1980; Reshetnikov 2003; Scott and Crossman 1974; Walters 1955

C. Problems, issues, or concerns for species

- Lack of information on this species, including life history, maturity, and population dynamics for management actions
- Taken as a food fish (mostly for dog food and/or traditional reasons) in the lower Yukon/Kuskokwim; human use not monitored

D. Location and condition of key or important habitat areas

- Key habitats are low-lying lakes and low velocity waterways in southwestern, western, and northern Alaska.
- Habitats are likely in near pristine conditions except near villages, where village growth and water treatment impoundments may have affected some localized habitats.

E. Concerns associated with key habitats

Water treatment impoundments, water withdrawals, and pollution; natural and anthropogenic filling of shallow lakes are potential threats

F. Goal: Conserve and manage blackfish populations throughout their natural range to ensure sustainable use of these resources.

G. Conservation objectives and actions

<u>Objective</u>: Maintain abundance, size, and age structure within natural variability throughout its native distribution in Alaska.

Target: Identify the native distribution of blackfish in Alaska.
Measure: Native and nonnative distribution within Alaska as determined by literature review and surveys in potential native habitat (e.g., Beringia, near margins of previously documented distributions) and nonnative habitat (e.g., Matanuska-Susitna valleys, Anchorage bowl, etc.).

Target: Identify and obtain size and age structure indices indicative of native blackfish populations in Alaska in index areas.
Measure: Documented size and age structure of native blackfish populations by surveys in index areas of Alaska to be determined.

Target: Abundance within the natural variability of known populations.
Measure: Native abundance estimates (as determined by cpue or mark-recapture) in Alaska within the bounds of 10-year cycles as determined by literature review and surveys in index areas to be determined.

Issue 1: Lack of information on this species: life history, population structure, migration patterns, distribution, trophic ecology, habitat characterization information (georeferenced).

Conservation actions:

a) Develop sampling protocols and implement sampling schedule across geographic range in Alaska.
b) Identify representative index areas.
c) Identify the habitat types or categories used by blackfish (e.g., as used in ADF&G's freshwater fish inventory database).
d) Map current distribution and other similar habitats for future investigation.
e) Develop a network of biologists/organizations to establish unified protocols, share data, leverage sampling efforts, and provide voucher specimens to museums (UAF, etc.); AFS-Alaska Chapter might be a venue for organizing and consolidating information.

Issue 2: Lack of harvest information.

Conservation actions:

a) Obtain local information and knowledge on local blackfish distribution, relative abundance, and harvest.
b) Develop sampling protocol to monitor magnitude and age structure of harvest.
c) Involve communities in monitoring, and share information.
d) Train local communities to monitor abundance, size structure, and harvest effort.

Issue 3: Alaska blackfish may be an important forage fish for various freshwater predators, some of which have been identified in this Strategy as of conservation concern (e.g., loons).

Conservation action: Determine the trophic ecology of Alaska blackfish.

Issue 4: Habitat alteration, sufficient water quantity and quality are potential concerns.

Conservation actions:

a) Determine habitat requirements and water quantity needs for all life history phases of blackfish.
b) Consider blackfish species when there are issues of habitat alteration (e.g., water withdrawals, wetland fills, pollution).
c) Develop a coordinated effort among government and nongovernment agencies to coalesce and exchange information on the habitat and water quantity needs of blackfish.

H. Plan and time frames for monitoring species and their habitats

State and federal agencies, universities, industry, Native entities, and NGOs should coordinate to conduct monitoring every year for 10 years to establish the target abundance index.

I. Recommended time frame for reviewing species status and trends

Review at 5 years to assess progress.

J. Bibliography

Aspinwall, N. 1965. Spawning characteristics and early life history of the Alaskan blackfish, *Dallia pectoralis* Bean [Master's thesis]. University of Washington, Seattle, WA.

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Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Bulletin 184. Ottawa, Canada.

Walters, V. 1955. Fishes of western arctic America and eastern arctic Siberia. Vol. 106, Article 5, American Museum of Natural History, New York.

Stickleback (Cook Inlet radiation)

Threespine stickleback and ninespine stickleback are both species complexes with many unique and reproductively isolated “species” (i.e., populations or potential subspecies) throughout their range. The threespine stickleback is a model species in the fields of evolutionary biology, developmental genetics, animal behavior, ecology, and environmental toxicology. Although neither species complex is in danger of decline (stickleback are often the most abundant species in an area), many unique populations and “species” are in serious decline or already extinct (Foster et al. 2003).

One of the most studied and remarkable threespine stickleback radiations exists in the Cook Inlet watershed in Southcentral Alaska. Stickleback scientists have studied this radiation intensively for the past 20 years and a large database has been built, including detailed information for over 200 populations on body armor, morphometrics, life history, behavior, trophic ecology, parasitology, and genetics. Populations in this radiation are now being used to study the genetic and behavioral mechanisms of rapid evolution and speciation, loss of skeletal elements (which has human medical implications, for example, for osteoporosis), evolution of development and developmental abnormalities, behavioral evolution, life history evolution, parasitism, genetic structure and function, and the effects of environmental contaminants. This database (and hence the populations under study) represents the most extensive stickleback database in the world, with important contributions in all of these fields of study. The threespine stickleback genome is currently being sequenced. The individual fish selected for sequencing came from Bear Paw Lake in the Cook Inlet watershed (F. von Hippel, personal communication). Therefore the scientific importance of these populations will increase greatly in the future. Additionally, a number of unique and important ninespine stickleback populations that have been studied exist in the Cook Inlet watershed.

In order to protect the scientific investment in these radiations and the future utility of these populations for ongoing scientific investigations, unique populations from both species complexes should be sustained. Many of these populations may be threatened by invasive northern pike (*Esox lucius*), human impacts on water quality, and salmonid stocking or introductions in isolated lakes (no inlet or outlet streams). Lessons learned from the conservation of threespine and ninespine stickleback radiations in Alaska may be applied to the conservation of similar radiations (e.g., Arctic char [*Salvelinus alpinus*], sockeye salmon [*Oncorhynchus nerka*], lake whitefish [*Coregonus clupeaformis*], rainbow smelt [*Osmerus mordax*], and lampreys [*Lampetra and Lenthenteron* spp.]) when their phenotypic diversity becomes better understood. Additionally, sticklebacks play an important role in the food webs of lakes and streams; they are, for example, a major source of prey for fish-eating birds, including species of conservation concern (e.g., loons).

A. Species group description

Common name: threespine stickleback
Scientific name: *Gasterosteus aculeatus*

Common name: ninespine stickleback
Scientific name: *Pungitius pungitius*

B. Distribution and abundance

Range: (Bell and Foster 1994)

Global range comments: Threespine stickleback: Marine, brackish and fresh waters in the Northern Hemisphere along both coasts of the Pacific and Atlantic Oceans, as well as in scattered populations along the Arctic Ocean and inland seas of Europe Ninespine stickleback: Marine, brackish and fresh waters throughout the high latitude Holarctic

State range comments: Threespine stickleback: Marine, brackish and fresh waters along the Gulf of Alaska, Bering Sea, and low-gradient rivers and lakes; a few populations occur on the North Slope

Ninespine stickleback: Marine, brackish and fresh waters from the Kenai Peninsula and Mat-Su Valleys west along the Gulf of Alaska, as well as along the Bering Sea and North Slope

Abundance:

Global abundance comments: Both species complexes are abundant through most of their ranges. One potential sub-“species” in the threespine stickleback species complex (the “unarmored threespine stickleback”) is a U.S. federally listed endangered species (in southern California). A number of other populations/“species” are in serious decline or extinct in certain parts of their range; for example, all 3 remaining benthic-limnetic species pairs in Canada are now listed as endangered (introduced brown bullheads [*Ameiurus nebulosus*] caused the extinction of the Hadley Lake species pair in the 1990s), and numerous unique populations in North America, Europe, and Japan are now extinct or threatened (Foster et. al. 2003).

State abundance comments: Abundant in lowland lakes and streams, as well as marine and brackish waters; some unique populations are in decline within the Cook

Inlet watershed due to invasive northern pike, human impacts on water quality, and stocking of salmonids in isolated lakes (no inlet or outlet streams).

Trends:

Global trends: Still abundant in most of range, but an increasing number of unique populations in decline or extirpated in parts of Europe, North America and Asia (Foster et. al. 2003).

State trends: Still abundant in most of Alaska, but an increasing number of unique populations or "species" that are in decline as part of the Cook Inlet radiation are in decline in Southcentral Alaska due to invasive northern pike, human impacts on water quality, and stocking or introduction of salmonids in isolated land-locked lakes (Patankar et al., in review).

C. Problems, issues, or concerns for species group

The conservation concerns are specifically for lakes and streams containing unique populations of threespine or ninespine sticklebacks in the Cook Inlet watershed.

- Lack of information on the lakes and streams with unique populations
- Lack of information on the distribution/occurrence of unusual stickleback populations
- Predation by invasive northern pike may be leading to population declines and possible loss of unusual forms of the radiation (Patankar 2004)
- Human impacts on water quantity and quality
- Stocking or other introduction of predatory fish species (e.g., salmonids) in lakes without inlet or outlet streams (isolated land-locked lakes), whether that stocking be an official program by ADF&G or inadvertent or intentional introductions by the public
- Sticklebacks are not taken for commercial or recreational fisheries

D. Location and condition of key or important habitat areas

- Key habitats are low-lying lakes and streams. Many of the unique populations exist in lakes without inlets/outlets (and hence no native salmonids).
- Habitats are likely in near pristine condition except in developed areas of Southcentral Alaska.
- Unique populations of the Cook Inlet radiation that merit conservation attention are known to exist in a number of lakes and streams throughout the Cook Inlet watershed. Authors of this template can provide a detailed list of such lakes upon request.

E. Concerns associated with key habitats

Predation by invasive northern pike

- Human impacts on water quantity and quality
- Stocking or other introduction of predatory fish species (e.g., salmonids) in lakes without inlet or outlet streams (isolated lakes), whether that stocking be an official program by the ADF&G or inadvertent or intentional introductions by the public

F. Goal: Conserve and manage unique populations of the threespine stickleback radiation and the ninespine stickleback radiation in the Cook Inlet watershed throughout their natural range to ensure sustainability of these resources.

G. Conservation objectives and actions

Objective: Maintain abundance within natural variability of threespine and ninespine stickleback populations in key lakes and streams (with unique populations) throughout the Cook Inlet watershed.

Target: Abundance within the natural variability for unique Cook Inlet populations.
Measure: Abundance estimates (as determined by cpue, mark-recapture or other methods) in unique populations in the Cook Inlet watershed within the bounds of 10-year cycles as determined by literature review and surveys.

Issue 1: Lack of information on the abundance indicative of viable populations for these lakes and streams with unique populations. Information for these lakes and streams is needed for life history, population structure, migration patterns, distribution, trophic ecology, and habitat characterization (georeferenced). Some of this information is known for each lake and stream known to contain a unique population, but much data still need to be collected; missing information varies by lake/stream.

Conservation actions:

a) Develop sampling protocols and implement sampling schedule for these unique populations.
b) Develop a network of stickleback biologists/organizations to establish unified protocols, share data, leverage sampling efforts, and provide voucher specimens to museums. Much of this network is already in place and simply needs to be formalized.

Issue 2: Lack of information on the distribution/occurrence of unusual stickleback populations. The Cook Inlet watershed contains numerous lakes, and although well over 200 lakes have been sampled, many hundreds have not; some may contain unique and important stickleback populations. Unusual populations of threespine and ninespine sticklebacks occur where conditions are unusual (e.g., lakes with low ionic strength water and lacking inlet or outlet streams). It is not practical to sample every lake and stream in the Cook Inlet watershed, but it is important to know where and how common these unusual populations are.

Conservation action:

a) Develop a series of proxies to identify candidate lakes for unusual stickleback populations, such as isolated lakes (especially with no outlet stream) as a proxy for evolutionary loss of body armor, relative area above the euphotic zone depth as a proxy for trophic form, and deep steep-sided lakes as a proxy for limnetic or highly variable populations. Other proxies could be developed to rapidly identify potential unusual populations. This can lead to an efficient sampling strategy designed to locate and count unusual populations. One criterion could be areas at risk (e.g., lakes that may experience or have experienced invasion by northern pike, lakes near towns or other types of developments, or lakes that might be stocked by ADF&G).

b) As soon as possible, develop and implement a lake stocking policy designed to protect nongame species of unique scientific interest or of conservation concern, such as some stickleback populations in the Cook Inlet watershed.

Issue 3: Predation by invasive northern pike in many of these lakes and streams may lead to declines in stickleback populations and may cause extinctions of populations (e.g., armor-reduced populations of threespine stickleback, such as in Prator Lake); such predation could also quickly lead to major changes in the phenotype of some populations (e.g., the evolution of more robust body armor), reducing the scientific value of those populations (Patankar 2004).

Conservation actions:

a) Develop a public education element (e.g., curriculum for high school biology classes, poster at ADF&G offices) that provides information on the importance of Alaskan sticklebacks as model systems in scientific investigations.
b) Implement strategies to rid key stickleback lakes of invasive northern pike (e.g., unlimited fishing on northern pike, seining for northern pike, etc.); avoid use of poisons, which would also rid lakes of their unique stickleback populations.
c) Implement strategies to prevent pike from invading additional lakes with unique stickleback populations.
d) Conduct public education on the importance of pike elimination and the need to stop illegal introductions of pike.

Issue 4: Humans are impacting water quantity and quality in many of these lakes and streams where unique stickleback reside (e.g., sedimentation, eutrophication, pollution, water withdrawal, etc.) due to road construction, housing development, mining, timber harvest practices, pollution from military installations, etc. Global climate change, the spruce bark beetle outbreak, and fire may also influence water quantity and quality.

Conservation actions:

a) Identify water quality problems in these lakes and streams and implement remedies.
b) Take preventative measures to avoid sedimentation in these lakes and streams from road construction and logging operations.
c) Ensure sufficient water quantity in lakes and streams where stickleback reside
d) Develop additional remedies for known threats to water quality and reassess as needed.

H. Plan and time frames for monitoring species and their habitats

Promote coordination with other state agencies, federal agencies, universities, industry, Native entities, and NGOs to conduct monitoring every year for 10 years to establish the target abundance index for these unique populations.

I. Recommended time frame for reviewing species status and trends

Review at 5 years.

J. Bibliography

Sticklebacks are among the most studied of all vertebrates, and hence the literature is extensive (many thousands of papers and a number of books published in the past 150 years). Here are a few key references pertinent to Alaskan populations:

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