



State of Utah
DEPARTMENT OF NATURAL RESOURCES
Division of Wildlife Resources – Native Aquatic Species

CONSERVATION AGREEMENT AND STRATEGY
FOR
LEAST CHUB
(IOTICHTHYS PHLEGETHONTIS)
IN THE STATE OF UTAH



Publication Number 05-24
Utah Division of Wildlife Resources
1594 W. North Temple
Salt Lake City, Utah
James F. Karpowitz, Director



State of Utah
DEPARTMENT OF NATURAL RESOURCES
Division of Wildlife Resources – Native Aquatic Species

CONSERVATION AGREEMENT AND STRATEGY
FOR
LEAST CHUB
(*IOTICHTHYS PHLEGETHONTIS*)
IN THE STATE OF UTAH

Prepared by:

Carmen L. Bailey
Kristine W. Wilson
Matthew E. Andersen

November 2005

Publication Number 05-24
Utah Division of Wildlife Resources
1594 W. North Temple
Salt Lake City, Utah
James F. Karpowitz, Director

The Utah Department of Natural Resources receives federal aid and prohibits discrimination on the basis of race, color, sex, age, national origin, or handicap. For information or complaints regarding discrimination, contact Executive Director, Utah Department of Natural Resources, 1636 West North Temple #316, Salt Lake City, Utah 84116-3193 or the Equal Employment Opportunity Commission, 1801 L Street, NW, Washington, D.C.20507

ACKNOWLEDGEMENTS

We thank the members of the Least Chub Conservation Team and other involved parties for their interest, cooperation, and contribution in revising and developing this document. Their involvement was an essential part of the completion of the Least Chub Agreement and Strategy. Karen Barnett, Mark Belk, Marianne Crawford, Joan Degiorgio, Russ Findlay, Richard Fridell, Chris Keleher, Tom Mendenhall, Mike Mills, Ben Nadolwski, Tom Pettengill, Rus Rader, Paul Thompson, Kevin Wheeler, Maureen Wilson, Elaine York provided valuable data and comments during the preparation of this document.

We would like to acknowledge M. Perkins, L. Lentsch and J. Mizzi as these individuals produced the 1998 Conservation Agreement and Strategy for Least Chub (*Iotichthys phlegethontis*) in the State of Utah. A substantial portion of this document was used from the 1998 publication.

The revision of this strategy was funded by the Utah Endangered Species Mitigation Fund and the United States Fish and Wildlife Service's State Wildlife Grant Program.

Cover: photograph by Mark Belk

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	iii
LIST OF TABLES	vi
LIST OF FIGURES	vii
DEFINITIONS AND ABBREVIATIONS	viii
CONSERVATION AGREEMENT	1
BACKGROUND	1
Goal:	1
Objectives:	1
I. OTHER SPECIES INVOLVED	1
II. INVOLVED PARTIES	2
III. AUTHORITY	2
IV. STATUS OF LEAST CHUB	3
V. PROBLEMS FACING THE SPECIES	3
VI. CONSERVATION ELEMENTS	4
VII. CONSERVATION SCHEDULE AND ASSESSMENT	4
Coordinating Conservation Activities	4
Implementing Conservation Schedule	5
Funding Conservation Actions	5
Conservation Progress Assessment	6
VIII. DURATION OF AGREEMENT	6
IX. NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) COMPLIANCE	6
X. FEDERAL AND STATE AGENCY COMPLIANCE	6
XI. LITERATURE CITED	7
XII. SIGNATORIES	7
CONSERVATION STRATEGY	15
INTRODUCTION	15
LIFE HISTORY	15
Historic Distribution	15
Current Distribution	17
Systematics and Taxonomy	18
Species Description	18
LEGAL STATUS	20
THREATS	20
Present or Threatened Destruction, Modification, or Curtailment	20
Predation, Competition, and Disease	21
Over utilization for Commercial, Recreational, Scientific, or Educational Purposes	21
Other Natural or Human Induced Factors	22
GOAL AND OBJECTIVES	22
CONSERVATION ELEMENTS	22
A. Habitat Enhancement	23
B. Habitat Protection	23
C. Restore Hydrologic Conditions	23
D. Nonnative Control	24
E. Range Expansion	24
Least Chub Inventory	24
Baseline Studies	24
Genetic Integrity	25
Refuges, reintroductions and introductions	25
F. Monitoring	25
G. Mitigation	26
H. Regulation	26
I. Information and Education	26

GEOGRAPHIC MANAGEMENT UNITS	28
WEST DESERT GEOGRAPHIC MANAGEMENT UNIT	28
Threats	28
West Desert GMU Conservation Elements.....	29
WASATCH FRONT GEOGRAPHIC MANAGEMENT UNIT	29
Threats	29
Wasatch Front GMU Conservation Elements.....	29
SEVIER RIVER GEOGRAPHIC MANAGEMENT UNIT	29
Threats	30
Conservation Team Management	30
LITERATURE CITED	34

LIST OF TABLES

Table 1. Summary of GMU Subunits.....	32
Table 2. Priorities of least chub conservation elements within each specific subunit.....	33

LIST OF FIGURES

Figure 1. Distribution of least chub in relation to historical Lake Bonneville.....	16
Figure 2. Least chub populations in Utah.....	17
Figure 3. Picture of Adult least chub.....	18
Figure 4. West Desert Geographic Management Unit.....	28
Figure 5. Wasatch Front Geographic Management Unit.....	29
Figure 6. Sevier River Geographic Management Unit.....	30
Figure 7. Adaptive management of the LCCAS.....	31

DEFINITIONS AND ABBREVIATIONS

For the purpose of this Agreement and Strategy, the following terms are defined as follows:

BLM – The Bureau of Land Management.

BOR – The Bureau of Reclamation.

Division – The Utah Division of Wildlife Resources.

Geographic Management Unit (GMU) - A distinct area, primarily within Utah, defined by the historic least chub range and hydrologic and geographic boundaries.

Historic Range - The area that least chub is perceived to have inhabited at the time of modern exploration and settlement of Utah (Approximately 1850).

Introduction - Release of wild or cultured least chub into historically unoccupied sites for aiding conservation.

LCCAS – The Least Chub Conservation Agreement and Strategy.

Nonnative - A species that historically did not occur in a specific area or habitat and that is now present usually as a result of human actions.

Reintroduction - Release of wild or cultured least chub into historically occupied sites for the purpose of reestablishing populations.

Service – The United States Fish and Wildlife Service.

Threat - Any action or activity, past or present, that currently or in the future may prevent the continued existence of least chub. Conditions such as pollution and the presence of nonnatives may also constitute threats.

Transplant/Translocate - Removal of least chub individuals from a naturally occurring population and subsequent release of these individuals into other waters for the purposes of establishing new or augmenting populations. Often conducted to provide additional security to guard against continued losses.

Mitigation Commission – The Utah Reclamation Mitigation and Conservation Commission

CONSERVATION AGREEMENT

FOR

LEAST CHUB (*Iotichthys phlegethontis*)

BACKGROUND

This Conservation Agreement (Agreement) has been developed to expedite implementation of conservation measures for least chub (*Iotichthys phlegethontis*) in Utah as a collaborative and cooperative effort among resource agencies. Threats that warrant least chub listing as a sensitive species by state and federal agencies and as threatened or endangered under the Endangered Species Act of 1973, as amended (ESA), should be significantly reduced or eliminated through implementation of this Agreement and the accompanying Conservation Strategy (Strategy).

Goal:

Ensure the long-term persistence of least chub within its historic range and support development of range-wide conservation efforts.

Objectives:

The following two objectives will be required to attain the goal of this strategy:

- Objective 1: To eliminate or significantly reduce threats to least chub and its habitat to the greatest extent possible.
- Objective 2: To restore and maintain self-sustaining populations throughout its historic range that will ensure the continued existence of least chub.

These objectives will be reached through implementation of the Strategy. The status of least chub will be evaluated annually to assess program progress and amendments will be added to address newly identified least chub recovery issues and to ensure program effectiveness. The parties to the Agreement understand that failure to implement the Least Chub Conservation Agreement and Strategy (LCCAS) or the failure of such measures to remove threats to the species' continued existence will be considered by the U.S. Fish and Wildlife Service (Service) in making its determination regarding whether listing of this species is required under the ESA

I. OTHER SPECIES INVOLVED

The primary focus of this agreement is the conservation and enhancement of least chub and the ecosystems upon which they depend; however, other species occurring within or adjacent to least chub habitat may also benefit. Some of these species include Columbia spotted frog (*Rana luteiventris*), California floater (*Anodota californiensis*), and Ute Ladies'-Tresses (*Spiranthes diluvialis*). By emphasizing the conservation of habitats and ecosystems where least chub occur, the accomplishment of actions identified in the Strategy should significantly reduce or eliminate threats

for several of these species, and the need for federal listing pursuant to the ESA.

II. INVOLVED PARTIES

Utah Department of Natural Resources
Division of Wildlife Resources
1594 West North Temple
Salt Lake City, Utah 84114

United States Department of the Interior
Fish and Wildlife Service
P.O. Box 25486
Denver, Colorado 80225

Bureau of Land Management
Provo Area Office
302 East 1860 South
Salt Lake City, Utah 84606-7317

Bureau of Reclamation
Upper Colorado Region
125 South State Street, RM 6107
Salt Lake City, Utah 84138-1102

Utah Reclamation Mitigation and Conservation Commission
102 W. 500 S. Suite 315
Salt Lake City, Utah 84101

Confederated Tribes of the Goshute Reservation
P.O. Box 6104
Ibapah, Utah 84034

Central Utah Water Conservancy District
355 West 1300 South
Orem, Utah 84058

III. AUTHORITY

The signatory parties hereto enter into this Agreement and the attached Conservation Strategy under federal law, as applicable, including, but not limited to Title 43, Section 24.6 of the Code of Federal Regulations, which states that "by reason of the Congressional policy (e.g., Fish and Wildlife Coordination Act of 1956) of State-Federal cooperation and coordination in the area of fish and wildlife conservation, State and Federal agencies have implemented cooperative agreements for a variety of fish and wildlife programs on Federal Lands", and state law, as applicable, under Title 23 Chapter 22.1 of the Utah Code stating that the "Division of Wildlife Resources may enter into cooperative agreements and programs with other state agencies, federal agencies, states, educational

institutions, municipalities, counties, corporations, organized clubs, landowners, associations, and individuals for purposes of wildlife conservation.”

All parties to this Agreement recognize that they each have specific statutory responsibilities that cannot be delegated, particularly with respect to the management and conservation of wildlife, its habitat and the management, development and allocation of water resources. Nothing in this Agreement or Strategy is intended to abrogate any of the parties' respective responsibilities.

This Agreement is subject to and is intended to be consistent with all applicable Federal and State laws and interstate compacts.

IV. STATUS OF LEAST CHUB

A decline in the abundance of least chub has been noted since the 1940's and 1950's (Holden et al. 1974) and studies conducted in the last 20 years indicate a continued decline in their distribution and abundance. In 1972, and again in 1979, least chub was recognized as a threatened species by the Endangered Species Committee of the American Fisheries Society (Miller 1972; Deacon et al. 1979). In 1980, the Service reviewed existing information on least chub and determined that there was insufficient data to warrant its listing as endangered or threatened. This finding was based on status reviews conducted by the Service. On December 30, 1982, the Service classified this species as a Category 2, Candidate (47 FR 58454). After preparation of a 1989 status report, the Service reclassified least chub as a Category 1, Candidate species (54 FR 554). In 1995, the Service determined that listing least chub as an endangered species was warranted and, on September 29, 1995, proposed to list the species as endangered with critical habitat, pursuant to the ESA (60 FR 50520). The improved status and the commitments made by signatories to the Conservation Agreement of 1998 (Perkins et. al., 1998) led the FWS to withdraw the listing proposal on July 29, 1999. Currently, least chub is classified as a Conservation Species by the State of Utah.

Commitments to carry out current and future actions identified in this Agreement and Strategy will be funded by a variety of sources. In 1992, Congress signed the Central Utah Project Completion Act. Under this act, funding was authorized for surveys of sensitive plant and animal species in Utah and mitigation for federal reclamation projects that impacted Utah fish, wildlife, and recreation resources. These federal funds are administered by the Utah Reclamation Mitigation and Conservation Commission. In 1997, the Utah State legislature passed a bill that established the Endangered Species Mitigation Fund (ESMF) thereby making money available on a competitive basis to benefit listed species and species of special concern. The Utah Division of Wildlife Resources (Division) has been using ESMF funding to provide the state match to the federal State Wildlife Grants.

V. PROBLEMS FACING THE SPECIES

The success of any conservation or recovery program depends on eliminating or reducing the impact of activities that threaten the species existence. For consistency, the general format is based on the five criteria considered for federal listing of a species in Section 4(a)(1) of the ESA.

1. The present or threatened destruction, modification, or curtailment of its habitat or range.
2. Disease, predation, competition and hybridization
3. Over utilization for commercial, recreational, scientific, or educational purposes.
4. The inadequacy of existing regulatory mechanisms
5. Other natural (e.g. drought) or human induced (e.g. socio-political) factors affecting its continued existence.

VI. CONSERVATION ELEMENTS

To meet the goal and objectives of this Agreement, the following conservation elements must be implemented:

- A. Habitat Enhancement** - Enhance and/or restore habitat conditions in designated areas throughout the historic range of least chub
- B. Habitat Protection** - Protect and enhance habitat (via land use changes) through land acquisition, conservation easements or regulatory mechanisms
- C. Restore Hydrologic Conditions** - Maintain, restore and augment where possible the natural hydrologic characteristics and water quality
- D. Nonnative Control** - Selectively control nonnative species that negatively impact least chub via predation and/or competition
- E. Range Expansion** - Conduct surveys, life history and genetic studies to determine habitat requirements for translocation of least chub into historic areas
- F. Monitoring** - Monitoring goals seeks to detect changes in population distribution over time
- G. Mitigation** - Develop site/action specific mitigation for proposed development activities as needed
- H. Regulation** - Maintain and enforce Utah Wildlife Code regulations that prohibit the collection, possession, and transportation of least chub.
- I. Information and Education** - Increase public awareness and support for the conservation of least chub.

VII. CONSERVATION SCHEDULE AND ASSESSMENT

Four general administrative actions, as outlined below, will be implemented.

Coordinating Conservation Activities

The Least Chub Conservation Team (LCCT) will consist of a designated representative from signatories to this Agreement and may include technical and legal advisors and other members as deemed necessary by the signatories.

Because the areas of concern covered by this Agreement are located in Utah, and because the State of Utah presently has primary jurisdiction over least chub within the State, the designated LCCT leader will be a Division representative.

Authority of LCCT shall be limited to making recommendations for the conservation of least chub. These recommendations will be implemented by Team members or contracted parties subject to review, and subsequent approval, by the Division Director for ecosystem conflicts and/or

opportunities for ecosystem-level or multi-species collaborative conservation. The Director will provide copies of comments, recommendations, and actions to the signatories and to other interested parties upon request.

The LCCT will meet annually to review yearly conservation schedules and budgets, and help develop funding as necessary.

The LCCT will meet at least semiannually to receive reports on progress and effectiveness of the Strategy implementation.

LCCT meetings will be open to interested parties. Minutes of the meetings and progress reports will be distributed to the LCCT, technical advisors and to other interested parties, upon request, by the LCCT leader.

The LCCT shall operate by consensus of the signatories when determining management recommendations concerning least chub protection and conservation. If consensus is not achieved, signatory parties with opposing views will present their positions to the Director of the Division of Wildlife Resources for resolution and determination of how to proceed. The Director shall notify all signatories of the inability to achieve consensus and of his determination.

Individual agency commitments for each participating agency are presented on signatory pages (Section XI).

Implementing Conservation Schedule

As leader of the LCCT, the Division will coordinate conservation activities and monitor conservation actions conducted by participants of this Agreement to determine if all actions are in accordance with the Conservation Strategy and annual schedule.

Conservation actions will be reviewed on an annual basis by the signatories.

Funding Conservation Actions

Funding for the Agreement will be provided by a variety of sources. Federal, state and local sources will provide or secure funding to initiate procedures of the Agreement and Strategy.

- Federal sources include, but are not limited to, the United States Fish and Wildlife Service, Bureau of Land Management, Utah Reclamation Mitigation and Conservation Commission, Bureau of Reclamation, Land and Water Conservation funds, the Natural Resource Conservation Service and State Wildlife Grants.
- State funding sources include, but are not limited to, direct appropriation of funds by the legislature, the Endangered Species Mitigation Fund, Community Impact Boards, Water Resources Revolving funds, State Department of Agriculture, and State Resource Management Agencies.
- Local sources of funding may be provided by water districts, Native American affiliations, cities and towns, counties, local irrigation companies, and other supporting appropriations and may be limited due to funding availability.

In-kind contributions in the form of personnel, field equipment, supplies etc., may be provided by participating agencies. In addition, each agency will have specific tasks, responsibilities and proposed actions/commitments related to their in-kind contributions.

It is projected that expansion of habitat and population actions will require the greatest expense during the first five years of the agreement.

It is understood that all funding commitments made under this Agreement are subject to approval by the appropriate local, state or federal authorities.

Conservation Progress Assessment

An annual assessment of conservation accomplishments identified in this Agreement and subsequent yearly schedules will be made by the LCCT. This assessment will determine the effectiveness of this agreement and whether revisions are warranted. It will be provided to the Division Director by the LCCT. The Director will provide copies of this assessment to the signatories of this document.

If threats to the survival of the least chub become known that are not or cannot be resolved through this or any Conservation Agreement, the Division will immediately notify all signatories.

VIII. DURATION OF AGREEMENT

The initial term of this Agreement shall be five years. Prior to the end of each five year period, a thorough analysis of actions implemented for the species will be conducted by the LCCT. If all signatories agree that sufficient progress has been made towards the conservation and recovery of the least chub, this Agreement shall be extended for an additional five years. Any party may withdraw from this Agreement on ninety (90) days written notice to the other parties.

IX. NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) COMPLIANCE

The Agreement and Strategy are being developed for planning purposes. Before any projects with a federal nexus which may impact the natural or human environment are scheduled for implementation they will be reviewed for the potential to require NEPA compliance (e.g. completion of an Environmental Assessment). Federal signatories to the Agreement will be consulted on any projects with the potential to require NEPA review and compliance.

X. FEDERAL AND STATE AGENCY COMPLIANCE

During the performance of this agreement, the participants agree to abide by the terms of Executive Order 11246 on non-discrimination and will not discriminate against any person because of race, color, religion, sex or national origin.

No member or delegate to Congress or resident Commissioner shall be admitted to any share or part of this agreement, or to any benefit that may arise there from, but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

All activities and programs conducted under this Agreement shall be subject to an conform with all

applicable state laws; including those laws contained in Title 23 of the Utah Code, Title 4, Chapter 37 of the Utah Code and all administrative rules and regulation promulgated thereunder.

XI. LITERATURE CITED

Deacon, J.E., G. Kobetich, J.D. Williams, and S. Contreras. 1979. Fishes of North America endangered, threatened, or of special concern: 1979. Fisheries 4(2):29-44.

Holden, Pl, W. White, G. Somerville, D. Duff, R. Gervais, and S. Gloss. 1974. Threatened fishes of Utah. Utah Academy of Science, Arts and Letters. 2(e):46-65.

Perkins, M., L.D. Lentsch, and J. Mizzi. 1998. Conservation agreement and strategy for least chub (*Iotichthys phlegethontis*) in the State of Utah. Utah Division of Wildlife Resources, Salt Lake City, Utah. Pub. Number 98-25.

Miller, R.R. 1972. Threatened freshwater fishes of the United States. Trans. Amer. Fish. Soc. 101(2):239-252.

XII. SIGNATORIES

The following pages include separate agreement pages for each signatory.

**UTAH DIVISION OF WILDLIFE RESOURCES
LEAST CHUB
CONSERVATION AGREEMENT**


The Utah Division of Wildlife Resources (Division) hereby states its intent and commitment to assist with, participate in, and lead the implementation of the Least Chub Conservation Agreement and Strategy, as prepared by the Least Chub Conservation Team. Specific commitments made are as follows:

1. To provide a representative to the Least Chub Conservation Team, which is made up of representatives from various agencies listed in the Agreement, to implement conservation elements described in the Strategy.
2. To assume lead responsibility for the inventory and monitoring of least chub populations in the State of Utah and to annually compile and report inventory and monitoring information and provide such information to all participating agencies and parties.
3. To make recommendations to the U.S. Army Corp of Engineers regarding the issuance of 404 permits for any land development proposals that would negatively impact key least chub habitats, and to work cooperatively with private land owners, land developers, and local land use planners in Utah to avoid, minimize and/or mitigate negative impacts of land development on least chub habitat.
4. To implement and enforce specific State statutes and Wildlife Codes (Wildlife Resources Code of Utah) that protects and prohibits the collection and/or importation of threatened, endangered and special concern species, including least chub.
5. To continue to conduct and support research to collect information on biotic and abiotic limiting factors of least chub populations, habitat and ecology and to work to reduce or eliminate limiting factors.

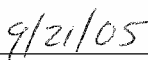
Performance of activities above is contingent on adequate funds being made available and allocated to the Division. This Agreement shall not prohibit the Division from engaging in management actions regarding least chub conservation beyond those described in this Agreement and Strategy. Such management actions will be coordinated with the Least Chub Conservation Team and other appropriate parties as deemed necessary.

This Agreement shall become effective on the date of signature by the Division, and shall remain in effect until the Division chooses to withdraw from the Agreement in whole or in part, or the Agreement is terminated by consent of the Least Chub Conservation Team. Either the Division or the Least Chub Conservation Team may terminate the Agreement by providing 90 days written notification to the other party.

By signing this document below, the Division acknowledges that it is also signing as a party and participant to the whole of the least chub conservation agreement attached hereto.



Jim F. Karpowitz, Director
Utah Division of Wildlife Resources



Date

**U.S. BUREAU OF RECLAMATION
LEAST CHUB
CONSERVATION AGREEMENT**

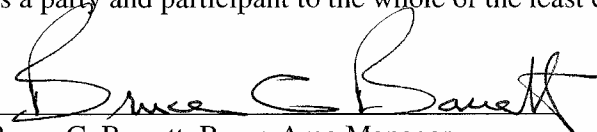
U.S. Bureau of Reclamation (Reclamation) hereby states its intent and commitment to assist with and participate in the implementation of the Least Chub Conservation Agreement and Strategy as prepared by the Least Chub Conservation Team. Specific commitments made hereby are as follows:

1. To provide a representative to the Least Chub Conservation Team, which will be made up of representatives from various state and federal agencies, tribes, and local entities.
2. To work in cooperation with the Least Chub Conservation Team and the State of Utah to conduct surveys on Reclamation lands, to assist with monitoring of any breeding populations that may be found on Reclamation land, and to cooperate and assist in eradication/control of non-indigenous species.
3. To consider possible impacts of Reclamation management plans on least chub and their habitat, and to take measures to avoid and/or mitigate such impacts whenever possible within the constraints of Reclamation policy and authority

Performance of all activities described above is contingent on adequate funds being made available and allocated to Reclamation. This agreement shall not prohibit Reclamation from engaging in management actions regarding least chub conservation beyond those described in this Agreement and Strategy. Such management actions will be coordinated with the Least Chub Conservation Team and other appropriate parties as deemed necessary.

This Agreement shall become effective on the date of signature by the participating party, and shall remain in effect until Reclamation chooses to withdraw from the Agreement in whole or in part, or the Agreement is terminated by consent of the Least Chub Conservation Team. Either Reclamation or the Least Chub Conservation Team may terminate the Agreement by providing 90 days written notification to the other party.

By signing this document below, the Bureau of Reclamation acknowledges that it is also signing as a party and participant to the whole of the least chub conservation agreement attached hereto.



Bruce C. Barrett, Provo Area Manager
U.S. Bureau of Reclamation, USDI

10/24/05
Date

US BUREAU OF LAND MANAGEMENT
LEAST CHUB
CONSERVATION AGREEMENT


The U.S. Bureau of Land Management (BLM) hereby states its intent and commitment to assist with and participate in the implementation of the Least Chub Conservation Agreement and Strategy as prepared by the interagency Least Chub Conservation Team. Specific commitments made hereby are as follows:

1. To provide a representative to the Least Chub Conservation Team, which will be made up of representatives from various agencies, as described in the Agreement.
2. To conduct a review of BLM lands in Utah which may occur within the historic range of the least chub, and determine if any such lands contain suitable habitat for least chub.
3. If least chub or suitable least chub habitats are found on BLM lands, work in cooperation with the Utah Division of Wildlife Resources to complete survey and monitoring of least chub populations and/or to evaluate habitat condition.
4. To maintain and improve habitat and populations of the least chub through adaptive management and mitigation on BLM lands. Authority for the protection of the least chub and its habitat is pursuant to provisions in the BLM Policy Manual and the Federal Land Policy and Management Act.

Performance of all activities described above is contingent on adequate funds being made available and allocated to the BLM. This Agreement shall not prohibit the BLM from engaging in management actions regarding least chub conservation beyond those described in this Agreement and Strategy. Such management actions will be coordinated with the Least Chub Conservation Team and other appropriate parties as deemed necessary.

This Agreement shall become effective on the date of signature by the BLM, and shall remain in effect until the BLM chooses to withdraw from the Agreement in whole or in part, or the Agreement is terminated by consent of the Least Chub Conservation Team. Either the BLM or the Least Chub Conservation Team may terminate the Agreement by providing 90 days written notification to the other party.

By signing this document below, the BLM acknowledges that it is also signing as a party and participant to the whole of the least chub conservation agreement attached hereto.


Utah State Director
U.S. Bureau of Land Management, USDI

9/28/05
Date

**UTAH RECLAMATION MITIGATION AND CONSERVATION COMMISSION
LEAST CHUB
CONSERVATION AGREEMENT**

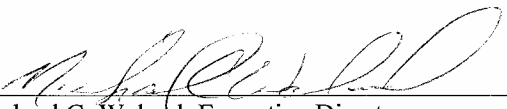
The Utah Reclamation Mitigation and Conservation Commission hereby states its intent and commitment to assist with and participate in the implementation of the Conservation Agreement and Strategy for the Least Chub, as prepared by the Least Chub Conservation Team. Specific commitments made are as follows:

1. To provide a representative to the Least Chub Conservation Team, which is made up of representatives from various agencies as described in the Strategy.
2. To incorporate least chub conservation actions to the appropriate Mitigation Commission programs, as described in the current Mitigation Commission's Final Mitigation and Conservation Plan. These may include, but are not limited to, the Statewide Program elements: Fish Hatchery Restoration and Construction, Sensitive Species Inventory and Database, Stream and Riparian Restoration Enhancement.
3. To protect least chub populations and suitable habitat on Mitigation Commission owned lands through appropriate management plans.

Performance of activities above is contingent on adequate funds being made available and allocated to the signatory agency. This Agreement shall not prohibit the signatory agency from engaging in management actions regarding least chub conservation beyond those described in this Agreement and in the conservation Plan. Such management actions should be coordinated with the Least Chub Conservation Team.

This agreement shall become effective on the date of signature by the participating party, and shall remain in effect until the signatory party to withdraw from the Agreement in whole or in part, or the Agreement is terminated by consent of the Least Chub Conservation Team. Either the signatory party may terminate their participation in or all signatories may terminate the agreement by providing 90 days written notification to the other parties.

By signing this document below, the Mitigation Commission acknowledges that it is also signing as a party and participant to the whole of the least chub conservation agreement attached hereto.



Michael C. Weland, Executive Director
Utah Reclamation Mitigation and Conservation Commission



Date

**US FISH AND WILDLIFE SERVICE
LEAST CHUB
CONSERVATION AGREEMENT**

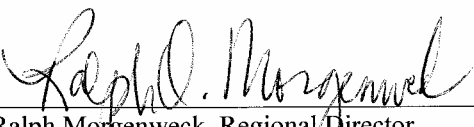
The U.S. Fish & Wildlife Service (Region 6) hereby states its intent and commitment to assist with and participate in the implementation of the Least Chub Conservation Agreement and Strategy, as prepared by the interagency Least Chub Conservation Team. Specific commitments made hereby are as follows:

1. To provide funding through the ESA Section 6 process to the Conservation Team and/or involved states for implementation of the Agreement.
2. To provide a representative to the interagency Least Chub Conservation Team.
3. To review and provide comments for any projects federally authorized, funded, or carried out that may impact the least chub, and under authority of the Fish & Wildlife Coordination Act, on projects requiring a Clean Water Act section 404 permit issued by the U.S. Army Corps of Engineers, or on water developments created by the Bureau of Reclamation or by private water development projects regulated under the Federal Energy Regulatory Commission.
4. Coordinate and assist other Federal agencies to protect least chub from land and water altering activities on Service lands that may harbor least chub.

Performance of all activities described above is contingent on adequate funds being made available and allocated to the signatory agency. This Agreement shall not prohibit the signatory agency from engaging in management actions regarding least chub conservation beyond those described in this Agreement and in the Strategy. Such management actions will be coordinated with the Least Chub Conservation Team and other appropriate parties as deemed necessary.

This Agreement shall become effective on the date of signature by the participating party, and shall remain in effect until the signatory party to withdraw from the Agreement in whole or in part, or the Agreement is terminated by consent of the Least Chub Conservation Team. Either the signatory party of the Least Chub Technical Team may terminate the agreement by providing 90 days written notification to the other party.

By signing this document below, the Service acknowledges that it is also signing as a party and participant to the whole of the least chub conservation agreement attached hereto.



Ralph Morgenweck, Regional Director
U.S. Fish & Wildlife Service, Region 6

9-27-05

Date

**CENTRAL UTAH WATER CONSERVANCY DISTRICT
LEAST CHUB
CONSERVATION AGREEMENT**

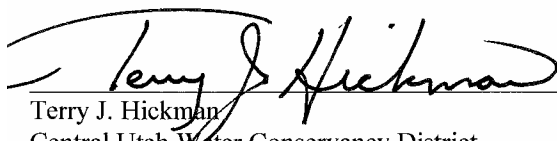
The Central Utah Water Conservancy District (District) hereby states its intent and commitment to assist with and participate in the implementation of the Least Chub Conservation Agreement and Strategy, as prepared by the interagency Least Chub Conservation Team. Specific commitments made hereby are as follows:

1. To provide a representative to the interagency Least Chub Conservation Team.
2. To work in cooperation with the state of Utah and other parties to this Agreement to implement actions identified in the Strategy.
3. To consider possible impacts of District activities and plans on least chub and their habitat, and avoid and/or mitigate such impacts whenever possible within the constraints of District policy and authority.

Performance of all activities described above is contingent on adequate funds being made available and allocated to the signatory agency. This Agreement shall not prohibit the signatory agency from engaging in management actions regarding least chub conservation beyond those described in this Agreement and in the Strategy. Such management actions will be coordinated with the Least Chub Conservation Team and other appropriate parties as deemed necessary.

This Agreement shall become effective on the date of signature by the participating party, and shall remain in effect until the signatory party to withdraw from the Agreement in whole or in part, or the Agreement is terminated by consent of the Least Chub Conservation Team. Either the signatory party of the Least Chub Technical Team may terminate the agreement by providing 90 days written notification to the other party.

By signing this document below, the Service acknowledges that it is also signing as a party and participant to the whole of the least chub conservation agreement attached hereto.



Terry J. Hickman
Central Utah Water Conservancy District

11 October 2005
Date

**CONFEDERATED TRIBES OF THE GOSHUTE RESERVATION
LEAST CHUB
CONSERVATION AGREEMENT**

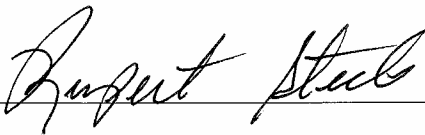
The Confederated Tribes of the Goshute Reservation hereby states its intent and commitment to assist with and participate in the implementation of the Least Chub Conservation Agreement and Strategy as prepared by the interagency Least Chub Conservation Team. Specific commitments made hereby are as follows:

1. To provide a representative to the Least Chub Conservation Team, which will be made up of representatives from various agencies, as described in the Agreement.
2. To conduct a review of Tribal lands in Utah which may occur within the historic range of the least chub, and determine if any such lands contain suitable habitat for least chub.
3. If least chub or suitable least chub habitats are found on Tribal lands, work in cooperation with the Utah Division of Wildlife Resources to complete survey and monitoring of least chub populations and/or to evaluate habitat condition.
4. To maintain and improve habitat and populations of the least chub through adaptive management and mitigation on Tribal lands.


Performance of all activities described above is contingent on adequate funds being made available and allocated to the Goshute Tribe. This Agreement shall not prohibit the Goshute Tribe from engaging in management actions regarding least chub conservation beyond those described in this Agreement and Strategy. Such management actions will be coordinated with the Least Chub Conservation Team and other appropriate parties as deemed necessary.

This Agreement shall become effective on the date of signature by the Goshute Tribe, and shall remain in effect until the Goshute Tribe chooses to withdraw from the Agreement in whole or in part, or the Agreement is terminated by consent of the Least Chub Conservation Team. Either the Goshute Tribe or the Least Chub Conservation Team may terminate the Agreement by providing 90 days written notification to the other party.

By signing this document below, the Goshute Tribe acknowledges that it is also signing as a party and participant to the whole of the least chub conservation agreement attached hereto.



Chairman



Date

CONSERVATION STRATEGY

FOR

LEAST CHUB (*Iotichthys phlegethontis*)

INTRODUCTION

The purpose of the Least Chub Conservation Strategy (Strategy) is to describe specific actions and approaches required to expedite implementation of conservation measures for least chub (*Iotichthys phlegethontis*). These actions will be implemented by the Least Chub Conservation Team (Team), which is comprised of representatives from each signatory to the Least Chub Conservation Agreement (Agreement). The goal of these actions is to ensure the long-term viability of least chub within its historic range. The general conservation approach focuses on two main objectives. The first objective is to eliminate or significantly reduce threats to least chub and its habitat. The second is to restore and maintain a minimum number of least chub populations throughout its historic range within designated Geographic Management Units (GMU) to help ensure the continued existence of least chub. The following document begins with a summary of current knowledge of least chub life history including population distributions, taxonomy, species descriptions, legal status, and ongoing threats to least chub. The subsequent sections describe conservation elements, which are specific management actions that will be implemented to reduce threats and expand least chub populations. The populations have been divided into separate GMUs along hydrologic drainages. Threats and conservation actions have been prioritized within each GMU in Utah. Lastly, the methodology of adaptive management and Strategy implementation is explained.

LIFE HISTORY

Historic Distribution

The Bonneville Basin within Utah encompasses the area that was covered by ancient Lake Bonneville and which, today, lies within the Great Basin physiographic province of North America. The entire Great Basin province is distinguished geologically by its characteristically parallel north-south mountain ranges that are separated by broad, alluviated desert basins and valleys (Christiansen 1951). In Utah, the steep, gravelly slopes of these ranges are prominently marked by benches and other shore features of Lake Bonneville. Numerous springs are present at the base of the mountains (Bick 1966) and in the valley floors. Several aquatic species have maintained an existence as relict populations in these springs, including the least chub, Columbia spotted frog (*Rana luteiventris*), and several species of mollusks. Populations of these species, however, are rare and in some areas declining. The rapid deterioration of these aquatic environments, primarily from water development and/or agricultural practices, has caused other unique Bonneville Basin species, such as *Rhinichthys osculus relictus* a subspecies of speckled dace, to become extinct (Hubbs et al. 1974).

The least chub are endemic to the Bonneville Basin of Utah where it was formerly widely distributed (Fig. 1). The species occupied a variety of habitats including rivers, streams, creeks, springs, ponds, marshes and swamps (Sigler and Miller 1963). Historically, least chub were found in streams near Salt Lake City, in freshwater ponds, swamps and tributaries around the Great Salt Lake, in Utah Lake, in and around the Provo River, Beaver River, Parowan Creek, and Clear Creek, in tributaries of Sevier Lake, and in springs in Snake Valley and in Utah Valley (Sigler and Sigler 1987).

The earliest records for least chub were by Dr. H.C. Yarrow and H.W. Henshaw in 1872 from the Beaver River, Utah (Cope and Yarrow 1875). They noted that this species was abundant in the areas where they made their collections. In 1889, D. S. Jordan collected least chub from the Provo River drainage and noted that they were “extremely common in the pools of water about the mouth of the Provo River and in the carp ponds next to Utah Lake” (Jordan 1891). Jordan and Evermann (1896) stated that the least chub occurred in “tributaries of Great Salt Lake and Sevier Lake” and that they were “excessively common in ponds and warm pools”. V. M. Tanner (1936) noted that the distribution of least chub included the Beaver River, Parowan Creek and Clear Creek. He also stated that it was “found in the Provo River and fresh water ponds around the Great Salt Lake. Tanner collected several specimens from the Provo River in 1931 as well.

Least chub have also been collected from the northeastern edge of the Bonneville Basin in Salt Lake and Davis counties. The Michigan Museum of Zoology contains specimens that were in a small brook outside of Salt Lake City in 1871 and again in 1933. Pendleton and Smart (1954) collected least chub in 1953 from Big Cottonwood Creek, in Salt Lake County and George Smith collected least chub near Centerville and in Farmington Bay, Davis County, in 1964 and 1965, respectively (Hickman 1989). The first recorded collection of least chub in Snake Valley was thought to be by C. Hubbs in Gandy Marsh in 1964.

An extensive least chub survey was conducted by Workman et al. (1979) in the Bonneville Basin. The only least chub populations located were from Snake Valley including the Gandy Marsh complex, Leland Harris Spring complex, Callao Spring complex, Twin Springs and in Redden Springs. No least chub were recorded in the lower reaches of the Ogden River, Big and Little Cottonwood Creeks, Provo River, or from numerous springs and ponds in Juab, Millard

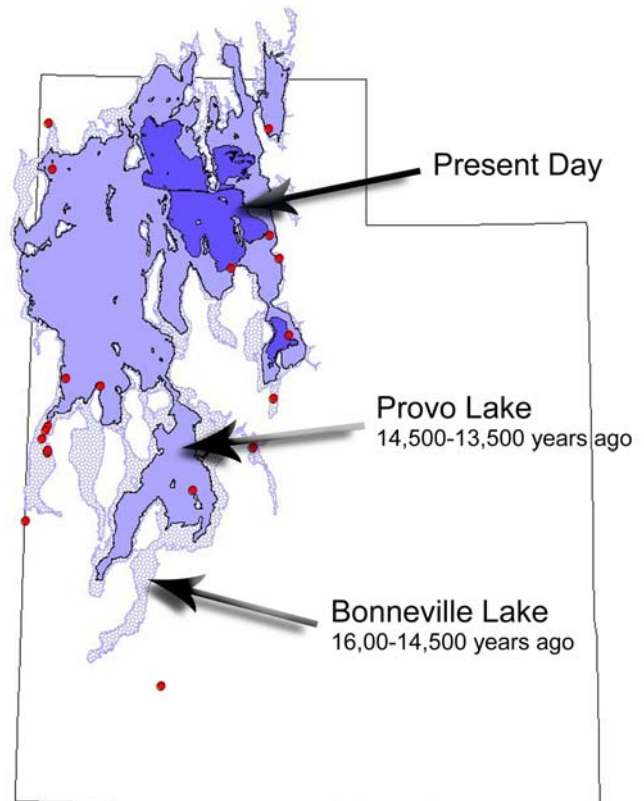


Figure 1. Current and historical distribution of least chub in relation to the receding Bonneville and Provo Lake shorelines.

and Tooele counties. Osmundson (1985) surveyed the same sites as Workman et al. did in 1977 and only found least chub in the Gandy Salt Marsh complex and Leland Harris Spring complex. He did, however, find least chub in Miller and Central Spring. Shirley (1989) surveyed the same springs in Callao but did not collect any least chub in these springs. Rosenfeld found a few least chub in Redden Springs during 1984 and indicated that they were not very abundant (Hickman 1989).

Current Distribution

The current distribution of least chub has expanded beyond the distribution limits of the 1980s due to a newly discovered population and several refuge sites. In the Utah's West Desert, least chub occur in Snake Valley in northwestern Utah in Gandy Marsh, Bishop Springs (Twin Springs) and Leland Harris Springs (Wheeler et al. 2004) (Fig. 2). Further surveys have confirmed that least chub have been extirpated from the Callao springs on the Bagley ranch and the Redden Springs complex (Crist 1990). Least chub have recently been transplanted to Walter Spring and Deadman Spring located at Fish Springs National Wildlife Refuge (Fig. 2) as an effort to establish additional populations and expand its range. In 1997, monitoring efforts confirmed that the populations were persisting in Walter Spring (Wilson 1999). More recent surveys in 2000-2001 have found a steady decline in least chub in Walter Spring most likely due to the re-invasion of mosquitofish (*Gambusia affinis*) (Wilson and Whiting 2002). Currently, there are efforts to make use of alternative water bodies at the Fish Springs National Wildlife Refuge as an additional genetic refuge for least chub.

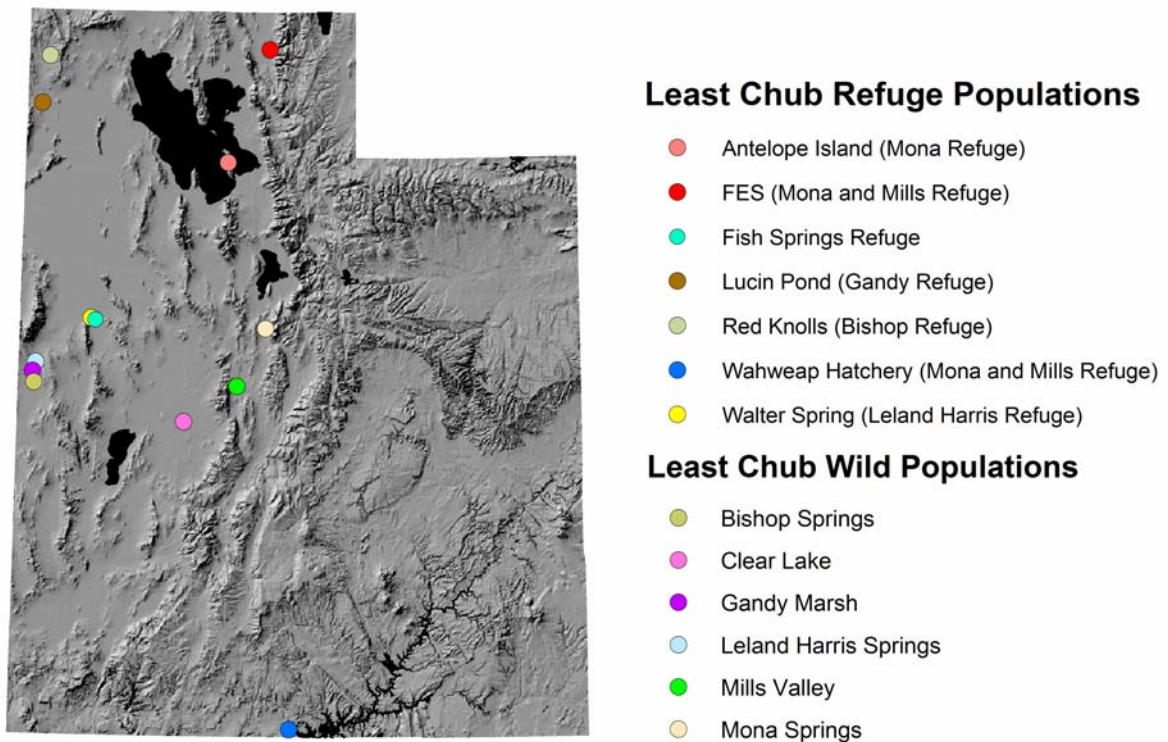


Figure 2. Least chub wild and refuge populations in Utah. *Note: Fish Springs is a proposed refuge site and does not contain least chub at the publication time of this document.*

Naturally occurring least chub populations are monitored in Mills Valley (in the Sevier drainage below Yuba Reservoir), and the Mona Springs complex (in the Utah Lake drainage) (Perkins et al. 1998, Wilson et al. 1999, Wilson and Whiting 2002). Utah Division of Wildlife Resources (Division) personnel discovered a previously undocumented population of least chub in the Clear Lake Wildlife Management Area (Fridell et al. 2004). Clear Lake WMA is within the Sevier River drainage and is owned and operated by the Division. A monitoring plan is currently being developed and will be added to the Division's annual state-wide monitoring efforts for least chub. Refugia for these natural populations have been established in Lucin Pond of western Box Elder County (Thompson 2004), Antelope Island within the Great Salt Lake (Thompson 2004), Red Knolls Spring (Thompson, pers. comm.), the Fisheries Experiment Station (Utah State Hatchery in Logan, UT) and in the Utah State Wahweap Fish Hatchery located in Big Water, UT.

Systematics and Taxonomy

The least chub is a small monotypic minnow endemic to the Bonneville Basin of Utah, which is located in the Great Basin of southwestern North America. The least chub is the sole representative of the genus *Iotichthys*. It was described by E.D. Cope (*Clinostomus phlegethontis*) from specimens collected in the Beaver River, southeastern Bonneville Basin, in 1872 by Dr. H.C. Yarrow and H.W. Henshaw (Cope and Yarrow 1875 in Hickman 1989). The genus was revised several times from *Clinostomus*, to *Gila* (Cope and Yarrow 1875), to *Phoxinus* (Jordan and Gilbert 1883), to *Hemitremia* (Jordan 1891), to *Leuciscus* (Jordan and Evermann 1896, who also listed it in the subgenus *Iotichthys*), and finally to *Iotichthys* (Jordan et al. 1930) (Hickman 1989).

Species Description

The least chub is a small cyprinid less than 6.35 cm, characterized by a very oblique mouth, large scales (34 to 38 along the side) and absence of a lateral line (rarely with one or two pored scales). It has a deeply compressed body, the pharyngeal teeth are in two rows, 2,5-4,2, the dorsal origin lies behind the insertion of the pelvic fin and the caudal peduncle is slender. The dorsal fin rays number eight or rarely nine, and it has eight anal fin rays (Sigler and Miller 1963)(Fig. 3).



Figure 3. Adult least chub (*Iotichthys phlegethontis*) (Photo by Mark Belk BYU).

The colorful least chub has a gold stripe along its blue sides with white-to-yellow fins. Males are olive-green above, steel blue on the sides, and have a golden stripe behind the upper end of the gill opening. The fins are lemon-amber, and sometimes the paired fins are bright golden-amber. Females and young are pale olive above, silvery on the sides, and have watery-white fins. They have silvery eyes with only a little gold coloration, rather than gold as in the males (Sigler and Miller 1963). The least chub was believed to be short lived, until recent studies have shown least chub to live up to 7 years of age (Mills et al. 2004a).

This species swims in rather dense, well-ordered schools but is very adept at diving into the bottom vegetation or retreating rapidly into rushes when disturbed. Least chub spawns in the

spring when water temperatures reach 16°C (60°F; Sigler and Sigler 1987). Least chub are polyandrous broadcast spawners over vegetation, primarily algae. They do not build nests or guard their young. The eggs are demersal and adhesive to the vegetation. Fertilized eggs hatch in about two days at a water temperature of 22°C (72°F; Crawford 1979). The presence of submerged vegetation provides an important habitat for eggs and larvae by furnishing needed oxygen and food (Crist and Holden 1980).

The least chub is a partial and intermittent spawner. Crawford (1979) found that least chub females produced only a few eggs at any time but release eggs over an extended period. The number of eggs produced at any one time is variable and may range from about 300 to 2700 (Sigler and Sigler 1987). Although peak spawning activity occurs in May, the reproductive season lasts from April to August, and perhaps longer depending on environmental conditions. Field studies have shown that changes in photoperiod or light intensity rather than increasing water temperature initiated the onset of egg development and spawning. Least chub were found to reproduce in the marshes when temperature, alkalinity, pH, and conductivity were at a maximum. Spawning was not observed in the springs, however, the fish move back into the springs after the spawning period. These unique reproductive strategies (movement, spawning over an extended period, broad tolerances to water quality extremes, and the ability to mature in one year) allow the least chub to successfully reproduce in the strongly fluctuating environment of the spring/marsh complexes (Hickman 1989).

Least chub are thought to be opportunistic feeders, their diets being related to the abundance or availability of food items during different seasons and from different habitat types (Crist and Holden 1980; Lamarra 1982). Common food items include algae, diatomaceous material, and midge adults, larvae, and pupae (Sigler and Sigler 1987). They also eat copepods, ostracods, and other invertebrates that are available (Hickman 1989). Workman *et al.* (1979) found that the diet of 121 least chub collected from various areas consisted of approximately 50% insects, 30% crustaceans, and 20% algae. They observed a reduced selection of algae during the winter and spring months. The least chub is of value to humans and other animals as a natural predator of mosquito larvae (Sigler and Sigler 1987), although mosquito larvae appears to be a seasonal food item.

Historically, least chub inhabited a variety of habitat types in different environments, including both lotic and lentic (Lamarra 1982; Sigler and Sigler 1987). The species was typically found in association with moderate to dense vegetation and in areas with moderate to no current (Sigler and Miller 1963).

Least chub is a generalist and has broad tolerance limits to many water quality parameters which allows it to exist in the severe environment of the springs and marshes in Snake Valley (Lamarra 1982). In general, the springs where least chub are still found exhibit cool stable temperatures, relatively low, stable dissolved oxygen values, and low conductivities. The marshes display higher temperatures, conductivity, pH and dissolved oxygen than the spring areas (Hickman 1989). The marshes also exhibit wide diurnal fluctuations in dissolved oxygen due to higher productivity. The daily temperatures in the marshes can fluctuate between 15 and 32°C (59-90°F; Crist and Holden 1980). Seasonal water quality changes in the marshes and stream segments result in fish movement back and forth between different habitat types, especially between springs and marshes (Crist and

Holden 1980). The presence of vegetation is an important habitat component for least chub, while substrate type appears to be insignificant (Crist and Holden 1980). Habitat usually consists of a small spring, pond or slough with a variety of herbaceous emergent, floating, and submergent vegetation. Vegetation most commonly associated with least chub includes: bullrush (*Scirpus sp.*), sedges (*Carex spp.*), cattails (*Typha sp.*), duckweed (Lemnaceae), rushes (*Juncus spp.*), watercress (*Nasturtium officinale*), grasses (Graminae) and algae. Additional species of vegetation found associated with the Snake Valley populations include saltgrass (*Distichilis spicata*), Elodea (*Elodia*), pondweed (*Xanthium spinosum* and *strumarium*), giant reed (*Phragmites*) and sandbar willow (*Salix sp.*). The occurrence of least chub populations in Snake Valley is ecologically intriguing because it has evolved life history traits that enable them to survive in isolated springs of high salinity and temperature.

LEGAL STATUS

This species has been declining since the 1940's (Holden et al. 1974; Workman 1979; Crist 1990). Least chub were recognized in 1972, and again in 1979, as a threatened species by the Endangered Species Committee of the American Fisheries Society (Miller 1972; Deacon *et al.* 1979). In 1980, the U.S. Fish and Wildlife Service (Service) reviewed existing information on least chub and determined that there was insufficient data to warrant its listing as endangered or threatened. This finding was based on status reviews conducted by the Service. On December 30, 1982, the Service classified this species as a Category 2 Candidate (47 FR 58454). After preparation of a 1989 status report, the Service reclassified the least chub as a Category 1 Candidate species (54 FR 554). In 1995, the Service determined that listing the least chub as an endangered species was warranted and, on September 29, 1995, proposed to list the species as endangered with critical habitat, pursuant to the ESA (60 FR 50520). Following conservation actions under the management of the interagency Least Chub Conservation Agreement and Strategy (Perkins et. al. 1998), the Service withdrew the proposed rule to list the least chub as endangered with critical habitat (64 FR 145). This species is currently classified as a sensitive species by the State of Utah (UDWR 2005).

THREATS

The success of any conservation or recovery program depends on eliminating or reducing the impact of activities that threaten the species' existence. In the proposed rule to list the least chub as an endangered species (60 FR 50518), the Service identified and described pertinent problems and threats facing the least chub. These threats were identified based on the criteria for Federal listing as required by Section 4(a)(1) of the ESA. The following discussion summarizes the significant threats to least chub that will be addressed by conservation actions described in this Strategy.

Present or Threatened Destruction, Modification, or Curtailment

Habitat loss and degradation have been indicated as major causes of the declines in least chub populations and distribution (Holden *et al.* 1974; Hickman 1989; Crist 1990). Although no studies have been made of the springs occupied by least chub, numerous other reports link livestock trampling and grazing with fish habitat degradation (water quality, vegetation type, habitat morphology, etc.) in streams and springs (Duff 1977; May and Somes 1981; Taylor *et al.* 1989, Fleischner 1994). The majority of occupied and unoccupied habitats are currently not protected

against grazing practices.

Water levels have been identified as important in the life history of least chub (Lamarra 1981; Crist and Holden 1990). Interest has been expressed in water development and mining activities within the Snake Valley (Kirby and Hurlow 2005). These activities could significantly lower the water table, possibly drying up or lowering the water level in springs and marshes populated by least chub. These springs are dependent on underground water sources that flow from the Deep Creek Mountains to the west side of the valley. Several water development activities (e.g. irrigation practices) have also altered the habitat of least chub along the Wasatch Front. Most springs along the Wasatch Front have been significantly altered as a result of diversion, capping, and pumping activities.

Predation, Competition, and Disease

Hickman (1989) considered least chub to be "constantly threatened" by the introduction and presence of nonnative species. Surveys of spring complexes indicate that where nonnative fishes were introduced, few if any least chub remain (Osmundson 1985). Introduced game fishes, including largemouth bass (*Micropterus salmoides*), rainbow trout (*Oncorhynchus mykiss*), common carp (*Cyprinus carpio*), and brook trout (*Salvelinus fontinalis*) are predators on least chub, and these species have been regularly stocked into least chub habitat (Workman *et al.* 1979; Sigler and Sigler 1987; Osmundson 1985; Crist 1990). In addition to game fish, other nonnative fishes also have been released into least chub habitat. The mosquitofish, rainwater killifish (*Lucania parva*), and plains killifish (*Fundulus zebrinus*) have been introduced into least chub habitats, have similar diets to the least chub and are considered potential competitors. The mosquitofish poses a direct threat to the least chub because of its known aggressive predation on eggs and young of other fishes (Meffe 1985; Sigler and Sigler 1987). A recent study found least chub juveniles to be the most vulnerable to mosquitofish predation (Mills *et al.* 2004).

Other potential predators on least chub include frogs, ducks, gulls, herons, and egrets (Osmundson 1985; Sigler and Sigler 1987). Under normal situations, predation from these sources would not negatively affect healthy populations of least chub. However, the combined effects of predation from the above sources, when populations are reduced by other factors, could result in further depletions of already fragile populations.

Disease or incidence of parasitism are not presently major factors affecting least chub. However, a single parasite called blackspot (*Neascus cuticola*) is known to infest least chub, although all infested least chub examined appeared to be robust and in good condition (Workman *et al.* 1979).

Over utilization for Commercial, Recreational, Scientific, or Educational Purposes

Over utilization for commercial, recreational, scientific or educational purposes does not currently pose a threat to least chub.

Other Natural or Human Induced Factors

Hybrid introgression between least chub and the Utah chub (*Gila atraria*) and speckled dace (*Rhinichthys osculus*) has been reported (Miller and Behnke 1985). Reproductive isolating mechanisms have apparently broken down in some areas due to habitat alteration and degradation. This has resulted in overlaps of reproductive niches and breakdowns of behavior due to overcrowding (Crawford 1979; Lamarra 1981). Least chub hybrids have been reported from springs near Callao, Utah, where non-hybridized least chub once existed (Miller and Behnke 1985). A recent molecular diversity study of least chub populations revealed no evidence for hybridization between least chub and Utah chub and suggest that early hybridization reports of may have been due to a misidentification of specimens (Mock and Miller 2003).

Another potential threat to the least chub is a proposed mosquito abatement program for Juab County. The Bureau of Land Management has rejected the County's request to implement a mosquito control spraying program in marsh and spring areas on BLM administered lands. The rejection does not prevent the county from spraying on privately owned lands. The effect of a mosquito control spraying program on least chub is uncertain. Past studies (Workman *et al.* 1979) indicate that much of the least chub diet is composed of insects, including mosquito larvae. To date, no studies have been undertaken to determine the effects of chemical toxins on the least chub or its environment.

GOAL AND OBJECTIVES

It is the goal of this strategy to ensure the continued persistence of least chub within its historic range and support development of range-wide conservation efforts. The following two objectives will be required to attain the goal of this strategy.

Objective 1: To eliminate or significantly reduce threats to least chub and its habitat to the greatest extent possible.

Objective 2: To restore and maintain self-sustaining populations throughout its historic range.

Objectives to meet the goal of this program are based on the historic range of the species. This format ensures that conservation actions are not limited to areas where least chub currently exist that may reflect habitat refugia rather than habitat preference.

CONSERVATION ELEMENTS

The following section outlines the general list of conservation actions or elements that will eliminate or reduce threats to least chub as well as expand its range back into historic localities. Each general element includes a list of specific methods, which may be implemented, either at a statewide level or site-specific level. Since the degrees of least chub management action will vary between least chub populations, specific conservation actions are prioritized and implemented within each GMU as described in the next section.

A. Habitat Enhancement

Enhance and/or restore habitat conditions in designated areas throughout the historic range of least chub.

1. Evaluate least chub habitat at each proposed enhancement site and possible reintroduction sites and assess habitat degradation, presence of nonnatives, disease and other threats.
2. Reduce or remove the identified threats to least chub.
3. Implement habitat enhancements that may include some or all of the following: bank stabilization, enhancement of native vegetation, dredging of springheads, riparian/spring fencing, nonnative removal, and implementing compatible grazing practices.
4. Maintain, restore and augment, where possible, the natural hydrologic characteristics and water quality.

Expected Products

- a. Increased suitable least chub habitat.
- b. Reduction of predation and competition risks from nonnative species.
- c. Reduction of future habitat degradation from erosion and ungulate grazing.

B. Habitat Protection

Protect and enhance habitat (via land use changes) through land acquisition, conservation easements or regulatory mechanisms.

1. Identify, prioritize, and protect least chub habitats.
2. Acquire conservation easements with landowners. The easements will provide for long-term habitat and water protection and provide habitat enhancement as needed.
3. Land and water acquisition as necessary in critical areas where conservation easements do not apply.
4. Develop cooperative agreements with landowners. The agreement will specify methods to eliminate or reduce those impacts on least chub habitats.
5. Develop agreements (Memorandum of Understanding (MOU), etc.) with local, state and federal agencies to protect least chub habitats as needed.

Expected Products

- a. Agreements, easements, acquisitions, and/or cooperative agreements with private landowners and/or public entities to protect least chub and its habitats as needed.

C. Restore Hydrologic Conditions

Maintain, restore and augment where possible the natural hydrologic characteristics and water quality. Specific actions will be identified within individual GMU's.

1. Identify water needs in current and potential least chub habitats.
2. Protect by acquisition, easement, MOU, and/or Cooperative Agreements.
3. Maintain natural hydrologic conditions.

Expected products

- a. Secure water sources for least chub habitats.

D. Nonnative Control

Selectively control nonnative species that negatively impact least chub via predation and/or competition.

1. Determine detrimental interactions with least chub and nonnatives (predation, competition, hybridization, or disease).
2. Control or modify stocking, introductions, and spread of nonnative aquatic species where appropriate.
3. Explore options to utilize least chub as a method of mosquito abatement in lieu of using nonnative western mosquitofish.
4. Reduce or eliminate detrimental species where feasible.

Expected Products

- a. Research identifying the negative impacts of nonnatives on least chub.
- b. Reduction of the spread of nonnative species and their impacts on least chub.

E. Range Expansion

Range expansion is a multistage process. The initial stages will begin by locating and assessing current least chub populations in Utah. Life history studies will establish the environmental and specific habitat requirements for least chub. Genetic research will determine the levels of molecular diversity within and between populations of least chub. Expansion of least chub populations and distribution will occur through introduction or reintroduction from either transplanted least chub or least chub raised in a designated hatchery facility.

Least Chub Inventory

1. Preliminary Survey (office oriented) - Intensive literature review of historic localities including museum records. Identify possible areas of occupation with aerial photography.
2. Reconnaissance (field oriented) - Site visit with ground-truthing. Conduct preliminary watershed/drainage basin assessment.

Expected Products

- a. Library of previous studies and relevant sampling methodology.
- b. Preliminary species and habitat list.
- c. Data from previous or similar studies.
- d. Information on present land use and habitat quality.
- e. Map of major habitat and population distribution.
- f. Initial assessment of potential gear and methodology.

Baseline Studies

1. Conduct an intensive habitat assessment. Use seasonal measurements describing spatial and temporal variation in physical, chemical and biological attributes. (Macrohabitat identification, substrate analysis, refuge assessment, bank condition, vegetation, water flow, water chemistry).
2. Gear evaluation of the most appropriate equipment to use to sample least chub.
3. Measure catch efficiency with mark-recapture and/or depletion studies.
4. Determine appropriate sampling method. Choose the appropriate number of

samples that minimize costs but still have enough statistical power to detect meaningful differences. Target all life stages if possible. Standardize sampling methodology.

Expected Products

- a. Habitat assessments.
- b. Analysis of temporal-spatial habitat and population variations.
- c. Species richness and abundance.
- d. Least chub population estimates.
- e. Selection of effective gear.
- f. Appropriate sampling methodology for comprehensive level monitoring program.

Genetic Integrity

1. Conduct genetic surveys to determine relatedness of any new least chub populations.
2. Establish introduction, reintroduction, and transplant protocols based on criteria of maintaining genetic integrity and maximizing genetic variability.
3. Establish at least two refuges for each of the three distinct genetic least chub populations.
4. Develop protocols to manage genetic drift between source and refuges.
5. Consider research into the reasons for differentiation among the three (maybe four) genetic groups.

Expected Products

- a. Data outlining the relatedness within and among least chub populations.
- b. Protocols to manage genetic drift.
- c. Recommendations for range expansion protocols.

Refuges, reintroductions and introductions

1. Establish permanent refuge populations in the Bonneville basin through reintroduction and introductions as per protocols established under Genetic Analysis.
2. Maintain hatching and rearing facilities. Identify and maintain wild populations as broodstock/refuges.
3. Evaluate opportunities with other conservation and recovery efforts for least chub range expansion.
4. Restore least chub to self-sustaining populations in appropriate areas.
5. Follow transplant protocols (Utah Code 23-14-21) by receiving approval from local government officials (e.g., County Commissions), the Resource Development Coordination Committee, and the Regional Advisory Councils).

Expected Products

- a. Expansion of least chub distribution and associated increased population stability.

F. Monitoring

Monitoring goals seeks to detect changes in population distribution over time. We propose to

accomplish this by using protocols to track least chub distribution within defined sampling populations and monitoring size class frequency within those sample populations.

1. Develop a strategy for implementing monitoring protocols by GMU. Population response monitoring associated with specific conservation actions will have a monitoring strategy tailored to address or determine the effectiveness of that specific action.
2. Collect / establish baseline habitat conditions at all occupied least chub locations. Evaluate conditions of populations and habitat conditions as necessary using baseline data. The habitat monitoring frequency and intensity will be triggered by environmental conditions and/or results from population monitoring. Biologists will monitor additional parameters (e.g., water level, precipitation), as necessary, to help interpret population fluctuations.
3. Maintain least chub database

Expected Products

- a. Habitat assessments of least chub populations.
- b. Habitat Management Plan for each least chub population.
- c. Baseline population data to monitor effectiveness of conservation actions.
- d. Evaluations of population health and security.
- e. Warnings when populations drop low will trigger additional study and appropriate conservation actions.

G. Mitigation

1. Develop site-specific mitigation for proposed water development and future habitat alteration, where needed.
2. Identify impacts from existing and proposed watershed development that affect least chub habitat. Impacts will be assessed and mitigation will be determined on a case-by case basis.

Expected Products

- a. Mitigation projects offsetting impacts to least chub and its habitat.

H. Regulation

1. Maintain and enforce current Utah Division of Wildlife Resources code regulations that prohibit the collection, possession, transportation, and importation of least chub and nonnative species.
2. Maintain consistency with the State of Utah Policy on Fish Stocking and Transfer Procedures.

Expected Products

- a. The regulations should eliminate the threat of over-utilization.
- b. Prevent stocking of species that could have a potentially negative impact to least chub and its habitat.
- c. Enforcement of violations and penalties.
- d. Improved communication and cooperation among local government and public interest groups.

I. Information and Education

Increase public awareness and support for the conservation of least chub.

1. Educate the public on the values of protecting ecosystems and restoring threatened species.

2. Produce and distribute educational information on least chub to the public and encourage other natural resource agencies to incorporate least chub awareness into their I and E programs.

Expected Products

- a. Educational products made available for schools, special interest groups and the public (i.e. fact sheets, posters, educational documents, interpretive signs, public website).
- b. Increased public support for conservation programs.

GEOGRAPHIC MANAGEMENT UNITS

Three Geographic Management Units (GMUs) have been identified for describing threats and actions for least chub: West Desert GMU, Wasatch Front GMU, and the Sevier River GMU (Figs. 4, 5, and 6). These units have been further divided into subunits consistent with the United States Geologic Survey hydrological description of Utah (USGS 1974) to assist in describing threats and prioritizing conservation measures to be implemented. These subunits have been assigned a name by the Division with a corresponding USGS accounting code as shown in Table 1.

WEST DESERT GEOGRAPHIC MANAGEMENT UNIT

This unit comprises nine hydrologic subunits (Table 1), seven of which have been prioritized for conservation actions (Table 2). Known populations of least chub that currently exist in this GMU are described below.

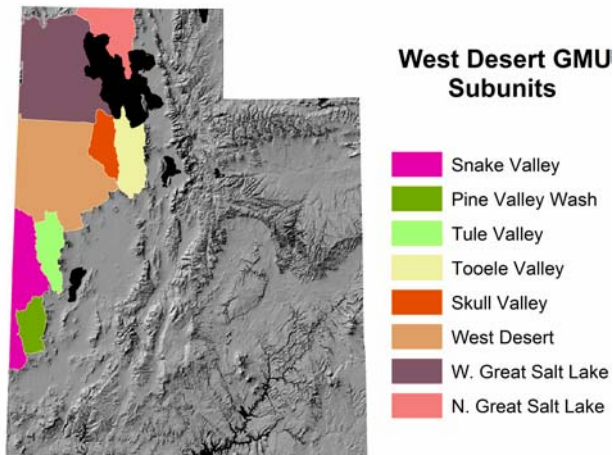


Figure 4. Management subunits within the West Desert GMU.

The Snake Valley Subunit is located between the Deep Creek Mountains and the Confusion Range. High priority areas within Snake Valley where least chub currently occur include Bishop Spring Complex (Foote Reservoir, Central Spring, and Twin Springs), Gandy Marsh spring complex, Leland Harris spring complex, and Miller Spring. Historic records of least chub have also been recorded in the Callao Spring and the Redden Spring complexes in the West Desert subunit.

In the West Great Salt Lake subunit, two refuge populations have been established. Least chub from Gandy Marsh were introduced into Lucin Pond, located in West Box Elder County, in 1989. A second refuge site was established on Antelope Island in Salt Lake County from the Mona Springs population in Juab County in 2004. An additional refuge was established at Red Knolls in 2005.

Threats

Habitat Degradation:

Major threats in this GMU are: degradation of habitat due to livestock grazing, oil and gas exploration, and alteration of wetland/spring complexes due to groundwater withdrawal. Livestock grazing specifically impacts the habitat by trampling shorelines, reducing vegetation, decreasing water quality, and accelerating succession of spring complexes. Oil and gas exploration may lead to a decrease in water quality, water contamination, and potentially alter groundwater pathways. Alterations to wetland/spring habitat include diversions for agricultural or municipal purposes. Water withdrawals are currently proposed to support human population growth in Southern Nevada may impact ground water levels in the Snake Valley (Kirby and Hurlow 2005).

Detrimental Interactions:

Several nonnative species have been introduced into some of the subunits for purposes ranging from mosquito abatement to recreational fishing opportunities. Competition and predation by nonnative species has significantly impacted least chub populations and poses a potential threat in this GMU.

West Desert GMU Conservation Elements

Habitat Protection, Nonnative Control, Range Expansion, Restore Hydrologic Conditions, Monitoring

WASATCH FRONT GEOGRAPHIC MANAGEMENT UNIT

This unit is comprised of eleven hydrologic subunits (Table 1), six of which have been prioritized for conservation actions (Table 2). Subunits where historic records of least chub and in some cases where empirical evidence suggests that least chub historically occurred include: Lower Bear River, Utah Lake, Provo River, Jordan River, and in the Lower Weber River. The only known population of least chub in this GMU is in the Utah Lake Subunit near the town of Mona. Refuge populations for the Mills Valley and the Mona populations have been established at the Utah Division of Wildlife Resources Fisheries Experiment Station in Cache County.

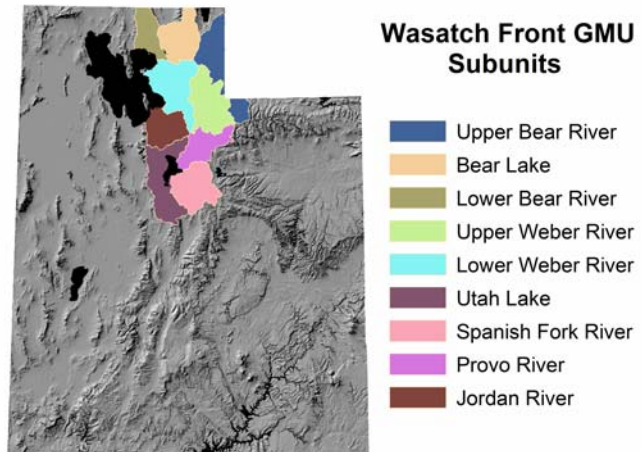


Figure 5. Management subunits within the Wasatch Front GMU.

Threats

Habitat Degradation:

The major threat in this area is loss of habitat due to human growth and water development for municipal and agricultural purposes. Agricultural areas and mountain foothills have been converted into neighborhoods and wetland areas in the valleys have been drained and diked. Water development projects have caused a reduction in habitat due to decreased water levels and elimination of habitat.

Detrimental Interactions:

Several nonnative fish species have been introduced into these areas for purposes of mosquito abatement and recreational fishing opportunities. Competition and predation by nonnative species have significantly impacted least chub populations and will continue to present a threat.

Wasatch Front GMU Conservation Elements

Inventories, Habitat Enhancement, Habitat Protection, Nonnative Control, Range Expansion, Monitoring, Restore Hydrologic Condition

SEVIER RIVER GEOGRAPHIC MANAGEMENT UNIT

This unit is comprised of nine hydrologically distinct subunits (Table 1), five of which have been prioritized for conservation actions (Table 2). Water in the Sevier River Basin historically flowed into pluvial Sevier Lake, but for the most part is currently diverted for agricultural purposes. The only populations known in this GMU occurs in the Lower Sevier River subunit, Mills Valley and in

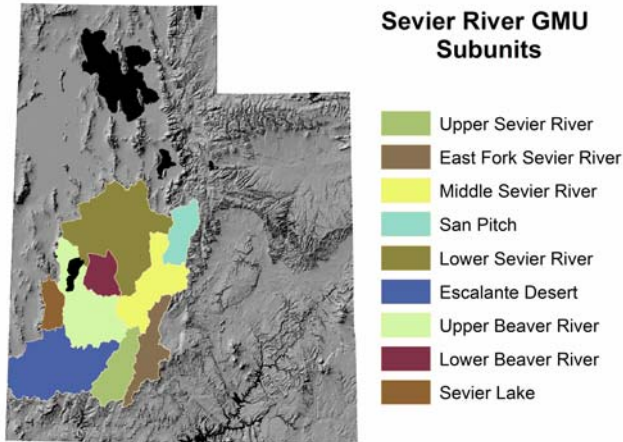


Figure 6. Management subunits within the Sevier River GMU.

Clear Lake Wildlife Management Area in the Lower Beaver subunit. Refuge populations for the Mills Valley and the Mona populations have been established at the Utah Division of Wildlife Resources Wahweap State Fish Hatchery Kane County. Historical least chub populations were known to occur within the Lower Beaver River and the Sevier Lake subunits

Threats

Habitat Degradation:

The major threat in this area is loss of habitat due to livestock grazing, water development for municipal and agricultural purposes and potential peat mining in the Mills Valley.

Livestock grazing specifically impacts the habitat by trampling banks, reducing vegetation, and decreasing water quality. Habitat alteration has caused significant losses in habitat due to wetlands being filled or drained to create additional land for agriculture and development. Water development projects have caused a reduction in habitat due to decreased water levels, capping and drying of spring complexes. Peat mining has the potential to permanently altering the hydrology and habitat complexity making it unsuitable for least chub.

Detrimental Interactions:

Several nonnative fish species have been introduced into these areas for purposes ranging from mosquito abatement to recreational fishing opportunities. Competition and predation by nonnative species has significantly impacted historical least chub populations and may continue to present a threat in this unit.

Sevier River GMU Conservation Elements

Inventories, Habitat Enhancement, Habitat Protection, Nonnative Control, Range Expansion, Monitoring, Restore Hydrologic Condition

CONSERVATION TEAM MANAGEMENT

The success of this Strategy will depend upon the ongoing cooperation among the signatories to the Agreement. Each signatory agency will continue their participation via a representative on the Least Chub Conservation Team. The primary duties of the Team include: coordination of conservation activities, review and revision of the Conservation Strategy (as needed), review of annual assessment report and the technical review of proposals and ongoing conservation activities.

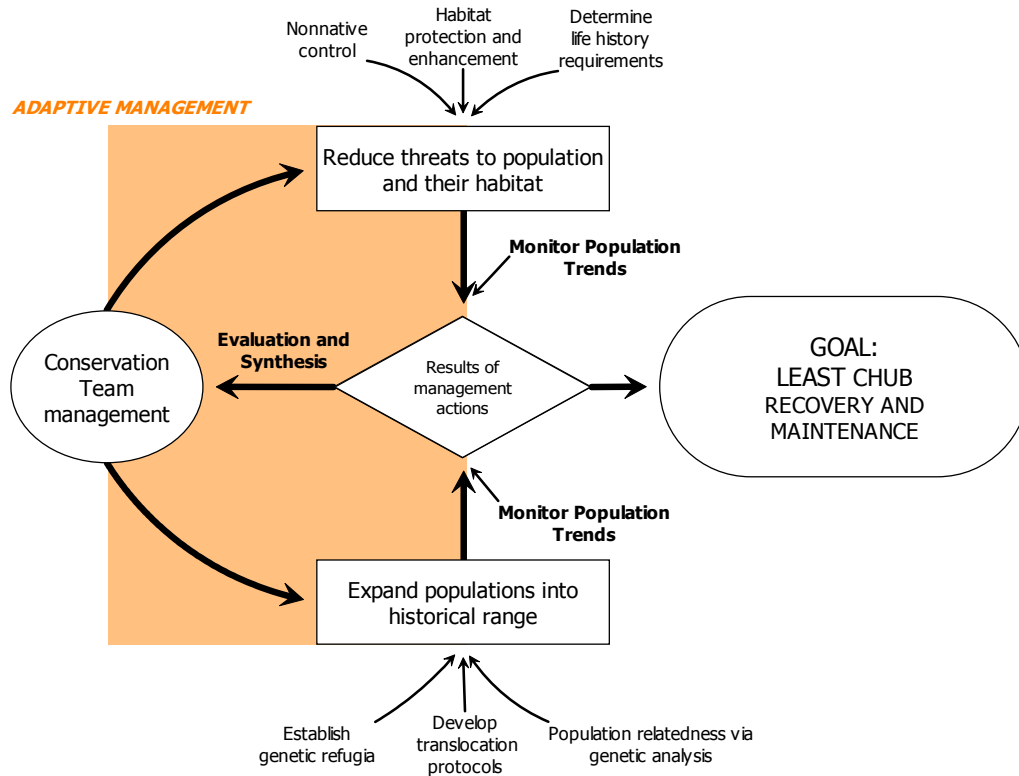


Figure 7. Diagram demonstrating the association of management actions to the goal of the LCCAS. Observing the population trends through the Division’s monitoring program will enable the Conservation Team to examine the effectiveness of their management decisions. The feedback from the results of the conservation actions allows for ongoing adaptive management of least chub activities.

The population and habitat data collected from the Division’s monitoring program has provided vital feedback on the management of least chub conservation actions. The Division’s monitoring program for the least chub has been ongoing for approximately 10 years. Monitoring population trends allows the Conservation Team to assess the effectiveness of their management actions. This method of adaptive management incorporates flexibility into conservation action (Fig. 7). “Specifically, it is the integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn” (Sapalsky et al. 2001). The results of the Team’s management actions are measured through monitoring population trends. Annual monitoring of least chub populations is the primary method to provide feedback to the Conservation Team and is the only method we have to measure and demonstrate the achievements of the Agreement and Strategy.

Table 1. Summary of GMU Subunits

GMU	SUBUNIT	SUBUNIT CODE (USGS 1974)	PRESENCE OF LEAST CHUB POPULATIONS	
			CURRENT	HISTORIC
West Desert	Snake Valley	16020301	X	X
	Pine Valley Wash	16020302		
	Tule Valley	16020303		
	Tooele Valley	16020304		X
	Skull Valley	16020305		
	West Desert	16020306		X
	W. Great Salt Lake	16020308	Refuge (2)	
	N. Great Salt Lake	16020309		
	Great Salt Lake	16020310	Refuge (1)	
	Wasatch Front	Upper Bear River	16010101	
Bear Lake		16010203		
Middle Bear River		16010202		
Lower Bear River		16010204		X
Upper Weber River		16020101		
Lower Weber River		16020102		X
Utah Lake		16020201	X	X
Spanish Fork River		16020202		
Provo River		16020203		X
Jordan River		16020204		X
Sevier River	Upper Sevier River	16030001		
	East Fork Sevier River	16030002		
	Middle Sevier River	16030003		
	San Pitch	16030004		
	Lower Sevier River	16030005		
	Escalante Desert	16030006		
	Upper Beaver River	16030007		
	Lower Beaver River	16030008	X	X
	Sevier Lake	16030009		X
Other	FES Hatchery		Refuge (2)	
	Wahweap Hatchery		Refuge (2)	

Table 2. Priorities of least chub conservation elements within each specific subunit.

GMU	Habitat Enhancement	Habitat Protection	Restore Hydrologic Conditions	Nonnative Control	Range Expansion	Monitoring	Mitigation	Regulation	I and E
West Desert									
Snake Valley	X	X	X	X	X	X	X	X	X
Tule Valley					X		X	X	X
Tooele Valley					X		X	X	X
Skull Valley					X		X	X	X
West Desert					X		X	X	X
W. Great Salt Lake		X		X		X	X	X	X
W. Great S Great Salt Lake					X	X	X	X	X
Wasatch Front									
Utah Lake	X	X	X	X	X	X	X	X	X
Spanish Fork River					X		X	X	X
Provo River					X		X	X	X
Jordan River					X		X	X	X
Lower Weber					X		X	X	X
Lower Bear River					X		X	X	X
Upper Bear River					X		X	X	X
Logan River						X	X	X	X
Sevier River									
Lower Sevier River	X	X	X	X	X	X	X	X	X
Lower Beaver River					X		X	X	X
Upper Beaver River					X		X	X	X
Sevier Lake					X		X	X	X
Escalante Desert					X		X	X	X
Other									
FES Hatchery						X			
Wahweap Hatchery						X			

LITERATURE CITED

- Bick, K. F. 1966. *Geology of the Deep Creek Mountains*. Utah Geology and Mineral Survey, Bull. 77:7-11.
- Crist, L. and P.B. Holden. 1980. *Aquatic biology study of a spring complex in Snake valley, Utah. Final Summary Report*. PR-36-1. BIO/WEST, Inc., Logan, Utah. 121 pp.
- Crist, L. 1990. *A Study/Monitoring Plan for Least Chub (Iotichthys phlegethontis) in Snake Valley*. Report prepared by Bio-Wes, Inc. for the Utah Division of Wildlife Resources.
- Christiansen, F.W. 1951. *Geology of the Canyon House and Confusion ranges, Millard County, Utah. Guidebook to the Geology of Utah*, #6:68-80.
- Cope, E.D. and H.C. Yarrow. 1875. Report upon the collection of fishes made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during the years 1871, 1872, 1873, and 1874. *Rept. Geog. and Geol., Expl. and Surv. W. 100th Merid.* (Wheeler Survey), 5:635-703.
- Crawford, M. 1979. *Reproductive modes of the least chub (Iotichthys phlegethontis - Cope)*. M.S. Thesis, Utah State University, Logan, Utah 78 pp.
- Deacon, J.E., G. Kobetich, J.D. Williams, and S. Contreras. 1979. Fishes of North America endangered, threatened, or of special concern: 1979. *Fisheries* 4(2):29-44.
- Duff, D. 1977. Big Creek aquatic habitat management and impacts from livestock grazing. Abstracts, *Bonneville Chapter American Fisheries Society*. 1977:3-6.
- Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. *Conservation Biology*, Vol. 8(3):629-644.
- Fridell, F. A., A. M. McLuckie, K.K. Wheeler, M. K. Morvilius, M. A. Schijf, M. R. M. Bennion, J. B. Coffey, M. A. Curtis, C. C. Ence, M. Geltch, J. A. Kohen, C. R. Lamere, E. W. Meyer, A.H. Rehm and C. J. Schena. 2004. *Southern Region Native Aquatics: FY04 Field Summary Program Report*. Utah Division of Wildlife Resources.
- Hickman, T.J. 1989. Status report of the least chub, *Iotichthys phlegethontis*, prepared for the U.S. Fish and Wildlife Service. *Western Ecosystems*, St. George, Utah. 20 pp.
- Holden, P., W. White, G. Somerville, D. Duff, R. Gervais, and S. Gloss. 1974. Threatened fishes of Utah. *Utah Academy of Science, Arts and Letters*. 2(2):46-65.
- Hubbs, C.L., M.M. Stevenson, and L.C. Hubbs. 1974. Hydrographic history and relict fishes of the North-central Great Basin. *Calif. Acad. Sci.* Vol. VIII. 259 pp.

- Jordan, D.S. 1891. Report of explorations in Colorado and Utah during the summer of 1889 with an account of the fishes found in each of the river basins examined. *U.S. Fish Comm. Bul.* 19(1889):1-40.
- Jordan, D.S., B.W. Evermann and H.W. Clark. 1930. Checklist of the fishes and fishlike vertebrates of North and Middle America north of the northern boundary of Venezuela and Columbia. *Rept. U.S. Fish Comm.* 1928(2):1-670.
- Jordan, D.S. and B.W. Evermann. 1896. The fishes of North and Middle America. Part 1. U.S. *Natl. Mus. Bul.* 47:1-1240.
- Kirby, S. and H. Hurlow. 2005. Hydrogeologic setting of the snake valley hydrologic basin, Millard County, Utah, and White Pine and Lincoln Counties, Nevada – implications for possible effects of proposed water wells. Report of investigation 254, Utah Geological Survey.
- Lamarra, M.C. 1982. *Status report of three Bonneville basin endemic fishes.* Prepared for the U.S. Fish and Wildlife Service. 27 pp.
- May, B. E. and W. L. Somes. 1981. Comparative effects of sheep and cattle grazing on the Marsh Creek drainage. *Transactions of the Bonneville Chapter American Fisheries Society.* 1981:48-62.
- Meffe, G.K. 1985. Predation and species replacement in American Southwestern fishes: a case study. *Southwestern Naturalist.* 30:173-187.
- Miller, D. L. and R. J. Behnke. 1985. Two New Intergeneric Cyprinid Hybrids from the Bonneville Basin, Utah. *Copeia*, 1985(2):509-515.
- Miller, R.R. 1972. Threatened freshwater fishes of the United States. *Trans. Amer. Fish. Soc.* 101(2):239-252.
- Mills, M. D., M. C. Belk, R. B. Rader and J. E. Brown. 2004a. Age and growth of least chub, *Iotichthys phlegethontis*, in wild populations. *West. N. American Naturalist* 64(3):409-412.
- Mills, M. D. R. B. Rader and M. C. Belk. 2004b. Complex interactions between native and invasive fish: the simultaneous effects of multiple negative interactions. *Oecologia* 141:713-721.
- Mock, K. E. and M. P. Miller. 2003. Molecular diversity within and among extant populations of least chub (*Iotichthys phlegethontis*). A report prepared for the Utah Division of Wildlife Resources, Native Aquatic Species Section.
- Osmundson, D.B. 1985. *1985 status survey of least chub (Iotichthys phlegethontis) in desert springs of western Utah.* Utah Division of Wildlife Resources. 107 pp.

- Paul, D.S. and J. Bich. 1987. *Least chub investigations, Box Elder County, 1985-1986*. Utah Division of Wildlife Resources, Salt Lake City, Utah.
- Perkins, M., L. D. Lentsch, and J. Mizzi. 1998. *Conservation agreement and strategy for least chub (Iotichthys phlegethontis) in the State of Utah*. Utah Division of Wildlife Resources, Salt Lake City, Utah. Pub. Number 98-25.
- Sapalsky, N. and R. Margoluis, K. Redford. 2001. *Adaptive Management: A Tool for Conservation Practitioners*. Report issued by the Biodiversity Support Program, Washington, DC.
- Sigler, W. F. and R.R. Miller. 1963. *Fishes of Utah*. Utah State Department of Fish and Game. 203 pp.
- Sigler W.F. and J.W. Sigler. 1987. *Fishes of the Great basin, a natural history*. University of Nevada Press. 425 pp.
- Taylor, F.R., L.A. Gillman and J.W. Pedretti. 1989. Impact of cattle on two endemic fish populations in Pahranaagat Valley, Nevada. *Great Basin Naturalist*. 49:491-495.
- Thompson, P. 2004. *Least Chub (Iotichthys phlegethontis) Management Activities in the Northern Region, 1998-2003*. Utah Division of Wildlife Resources. Pub. Number 04-14.
- U. S. Fish and Wildlife Service (USFWS). 1995. Proposal to determine the least chub (*Iotichthys phlegethontis*) an endangered species with critical habitat. *Federal Register*. Vol. 60, No. 189. September 29, 1995. pp. 50518-50530.
- U. S. Geological Survey. 1974. Hydrologic Unit Map, State of Utah. Reston, VA.
- Utah State Division of Wildlife Resources. 2005. *Sensitive Species List*.
<http://www.wildlife.utah.gov/publications/>
- Wheeler, K. K., R. A. Fridell and J. A. Bryant. 2004. *Least Chub (Iotichthys phlegethontis) Monitoring Summary: Snake Valley, 2004*. Utah Division of Wildlife Resources, Salt Lake City, Utah. 22 pp.
- Wilson, K. W., C. K. Balcombe, and B. W. Thompson. 1999. *Least chub monitoring survey Central Region 1999*. Utah Division of Wildlife Resources, Salt Lake City, Utah.
- Wilson, K. W. and J. C. Whiting. 2002. *Least Chub Monitoring Survey Central Region, 2000*. Utah Division of Wildlife Resources, Salt Lake City, Utah. 47 pp.
- Wilson, K. W. and M. D. Mills. 2005 *Least Chub Monitoring Survey Central Region, 2004*. Utah

Division of Wildlife Resources, Salt Lake City, Utah. 14 pp.

Workman , G.W., W.G. Workman, R.A. Valdez, W.F. Sigler and J.M. Henderson. 1979. *Studies on the least chub in geothermal active areas of western Utah*. Contract No. YA-512-CT7-21, USDI Bureau of Land Management, Utah State Office. 348 pp.