Los Angeles Department of Water & Power

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April 29, 2016

Ms. Barbara Evoy, Deputy Director
Division of Water Rights
State Water Resources Control Board
1001 I Street, 14th Floor
Sacramento, California 95814

Dear Ms. Evoy:

Subject: Compliance with State Water Resources Control Board Order Nos. 98-05 and 98-07

Pursuant to the State Water Resources Control Board Decision 1631 and Order Nos. 98-05 and 98-07 (Orders) and in accordance with the terms and conditions of the Los Angeles Department of Water and Power (LADWP) Mono Basin Water Right License Nos. 10191 and 10192, enclosed is a compact disc (CD) containing "Mono Basin Compliance Reporting May 2016", which contains the following four reports required by Orders. Reports are as follows:

- Mono Basin Operations: Runoff Year (RY) 2015-16 and planned operations for RY 2016-17
- Mono Basin Fisheries Monitoring Report: Rush, Lee Vining, Parker, and Walker Creeks for RY 2015-16
- Stream Monitoring Report for RY 2015-16
- Mono Basin Waterfowl Habitat and Population Monitoring for RY 2015-16

In addition to these reports, the submittal also includes Section 1: RY 2015-16 Status of Restoration Compliance Report, which summarizes the status of LADWP's compliance activities in the Mono Basin to-date and planned activities for the upcoming runoff year.

Filing of these reports, along with the restoration and monitoring performed by LADWP in the Mono Basin, fulfills LADWP's requirements for RY 2015-16, as set forth in Decision 1631 and Orders.

111 N. Hope Street, Los Angeles, California 90012-2607 *Mailing address:* Box 51111, Los Angeles, CA 90051-5700
Telephone: (213) 367-4211 www.LADWP.com

Electronic copies of the Compliance Reporting May 2016 submittal on CD will be provided to the interested parties listed on the attached mailing list. Hard copies of the report will be provided upon request.

If you have any questions, please contact Mr. Peter Tonthat, Civil Engineering Associate II, at (213) 367-1792.

Sincerely,

Richard F. Harasick
Director of Water Operations

PNT:jem
Enclosure
c/enc.: Mr. Peter Tonthat

Mono Basin Distribution List
<u>Runoff Year 2015-2016</u>

Ms. Barbara Evoy Division of Water Rights State Water Resources Control Board 1001 I Street, 14th Floor Sacramento, CA 95814	Ms. Lisa Cutting Mono Lake Committee P.O. Box 29 Lee Vining, CA 93541
Ms. Amanda Montgomery Division of Water Rights State Water Resources Control Board 1001 I Street, 14th Floor Sacramento, CA 95814	Board of Supervisors Mono County P.O. Box 715 Bridgeport, CA 93517
Mr. Scott McFarland Division of Water Rights State Water Resources Control Board 1001 I Street, 14th Floor Sacramento, CA 95814	Dr. Mark Drew California Trout Inc. P.O. Box 3442 Mammoth Lakes, CA 93546
Dr. William Trush Humboldt State University River Institute c/o Department of Environmental Science and Management 1 Harpst Street Arcata, CA 95521-8299	Mr. Richard Roos-Collins Water and Power Law Group 2140 Shattuck Avenue, Suite 801 Berkeley, CA 94704-1229
Mr. Ross Taylor 1254 Quail Run Court McKinleyville, CA 95519	Mr. Marshall S. Rudolph Mono County Counsel P.O. Box 2415 Mammoth Lakes, CA 93546
Mr. Jon C. Regelbrugge USDA U.S. Forest Service P.O. Box 148 Mammoth Lakes, CA 93546	Mr. Steve Parmenter Department of Fish and Wildlife 787 North Main Street, Suite 220 Bishop, CA 93514
Ms. Tamara Sasaki California Department of Parks and Recreation P.O. Box 266 Tahoma, CA 96142	Mr. Doug Smith Grant Lake Reservoir Marina P.O. Box 21 June Lake, CA 93529
Mr. Matthew Green California State Parks 3415 Hot Springs Road Markleeville, CA 96120	

In Response to the
State Water Resources Control Board
Order Nos. 98-05 and 98-07

COMPLIANCE REPORTING

Mono Basin Operations
Fisheries Monitoring
Stream Monitoring
Waterfowl Habitat & Population Monitoring

May 2016

Los Angeles Department of Water and Power

C O N T E N T S

Section 1

Status of Restoration Compliance Report

Status of Restoration Compliance Report (SORC)

Compliance with State Water Resources Control Board Decision 1631 and Order Nos. 98-05 and 98-07

May 2016

Los Angeles Department of Water and Power

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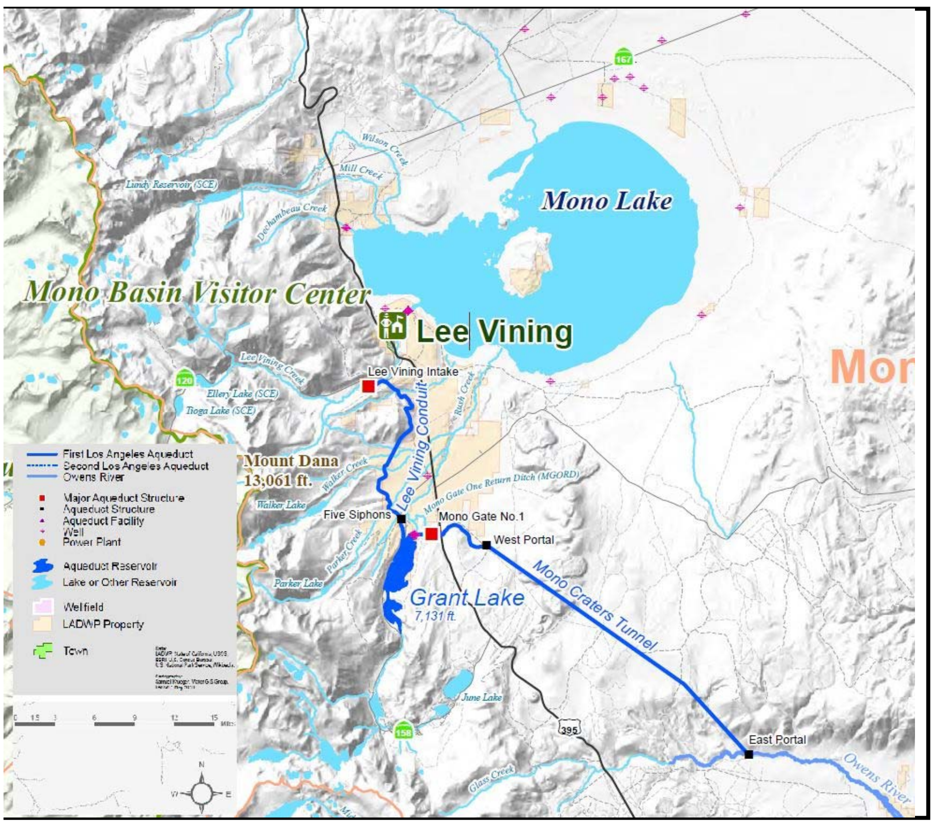
Introduction

Pursuant to State Water Resources Control Board (SWRCB) Decision 1631 and Order Nos. 98-05 and 98-07 (Orders), the Los Angeles Department of Water and Power (LADWP) is to undertake certain activities in the Mono Basin to be in compliance with the terms and conditions of its water right licenses 10191 and 10192. In particular, the Orders state that LADWP is to undertake activities to monitor stream flows, and to restore and monitor the fisheries, stream channels, and waterfowl habitat. This chapter includes the Status of Restoration Compliance Report, which summarizes the status of LADWP compliance activities in the Mono Basin to date. It is expected that the Water Board will amend LADWP's water rights license. Following SWRCB adoption of the amended license, the new requirements will be reflected in future SORC Reports.

Figure 1: Map of Mono Basin showing major Streams and LADWP facilities.



Status of Restoration Compliance Report

This document was first submitted as draft to the interested parties on April 1, 2016. It was developed to include a 21 day review period during which LADWP will review and address comments submitted by the interested parties. Following the 21 day review period, LADWP will finalize it as part of the May 2016 Status of Restoration Compliance Report as below.

Status of Restoration Compliance Report
State Water Resource Control Board Decision 1631 and Order Nos. 98-05 & 98-07

The Status of Restoration Compliance Report ("SORC Report") is organized into the following sections:

1. **Introduction** – Description of the SORC Report
2. **Definitions** – Explanations of what each category represents
3. **Updates from Previous SORC Report** – Changes over the past year
4. **Plans for the Upcoming Runoff Year** – Planned activities for the upcoming year
5. **Requirements** – Categories of the entire list of LADWP's requirements in the Mono Basin
6. **Completion Plans** – Long term plans for completing all requirements
7. **Ongoing Items Definitions** – Ongoing activities necessary for LADWP operations in the Mono Basin.

1. Introduction:

The SORC Report details the status of the Los Angeles Department of Water and Power's (LADWP) restoration requirements in the Mono Basin as outlined by the State Water Resources Control Board (SWRCB) Decision 1631 and Order Numbers 98-05 and 98-07, and any subsequent decision letters distributed by the SWRCB. This initial structure and content of the SORC report was cooperatively prepared by LADWP and the Mono Lake Committee (MLC) through an extensive series of staff discussions and a workshop held in the Mono Basin in August 2005. LADWP and MLC believe this report represents the most thorough and complete listing of Mono Basin restoration requirements and their current status available in a unified document. These requirements are categorized as ongoing, complete, in progress, incomplete or deferred as defined below in Section 2. The final section of the SORC Report details how LADWP plans to proceed with those items not listed as ongoing or completed (i.e. items in progress, incomplete, and/or deferred).

The SORC Report will be submitted by LADWP to SWRCB as part of the annual Compliance Reporting. By April 1 each year, LADWP will update and submit a draft SORC Report to the interested parties. Within 21 days of the draft submission, LADWP will accept comments on the draft SORC Report from the interested parties. Then, LADWP will finalize the SORC Report, incorporating and/or responding to comments. The final SORC Report will then be included into the final Compliance Reporting to SWRCB by May 15 of each year.

It is expected that the Water Board will amend LADWP's water rights license in 2016. The new requirements are expected to take effect immediately after the Water Board issues an order, and those new requirements will be reflected in future SORC Reports. Any items no longer relevant under the new order will be moved to a new category "Eliminated" in the SORC. The new SORC will show both a new numbering system for all active items as well as the old numbering system for cross reference. Once agreement is reached on the items in the "eliminated" category, those items as well as the old numbering will no longer be shown in future SORC Reports.

2. Definitions:

Below are the definitions of the categories where each requirement has been grouped.

A. Ongoing — Items that are current and require continuous action (e.g. Maintain road closures in floodplains of Rush and Lee Vining Creeks)

B. Complete — Items that have been finalized (e.g. Rehabilitation of the Rush Creek Return Ditch)

C. In-Progress — Items started and not yet finalized because of time or the timeline extends into the future (e.g. Waterfowl monitoring and reporting)

D. Incomplete — Items not yet started or not complete because plans for completion not finalized.

E. Deferred — Items placed on hold which need input from the Stream Scientists and/or SWRCB before plans commence (e.g. Prescribed burn program)

3. Updates from Previous SORC Report:

Since the last SORC Report of May 15, 2015, there have been changes in the report, and those are outlined below.

- Section 4, Plans for the Upcoming Runoff Year, has been updated to cover Runoff Year 2016-2017 (RY 2016-17).
- Section 5, In-Progress Item C4, "Grant Lake Operation Management Plan (GLOMP)", will be replaced with "Mono Basin Operations Plan (MBOP)", once the SWRCB issues a new amended Water Rights license. The "Mono Basin Operations Plan" will contain requirements of the new amended Water Rights license.
- Section 5, Deferred Item E3 moved to Category B "Completed Items". Rehabilitation of the Rush Creek Return Ditch.

4. Plans for the Upcoming Runoff Year:

During the upcoming runoff year, RY2016-17, LADWP plans to:

1. Continue with all requirements listed under Category A – Ongoing Items, as needed based on the runoff year.
2. Continue Category C – In-Progress Items C17 "Sediment Bypass for Parker Creek". Sediment bypass will continue in the next non-Dry RY.
3. Continue Category C – In-Progress Items C18 "Sediment Bypass for Walker Creek". Sediment bypass will continue in the next non-Dry RY.

5. Requirements:

This section lists and categorizes the individual requirements based on the status of each item. The requirements are derived from SWRCB Decision 1631, and/or Order Nos. 98-05 and 98-07, and/or any subsequent decision letters distributed by SWRCB. The requirements are either described in the cited section of the order and/or are described in the cited page of the specified plan and/or document (Stream Plan, Waterfowl Plan, GLOMP, etc.) that the Order references, and/or detailed in the SWRCB letter. Plans for completing in-progress, incomplete, and deferred items are further explained in Section 6, Completion Plans. Finally, plans for those items described as ongoing are detailed in Section 7, Ongoing Items Description.

Category A – Ongoing Items

1. Maintain road closures in floodplains of Rush and Lee Vining Creeks – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 71-75

2. Base flow releases – *Stream Management*
   Order 98-05 order 2.a.; GLOMP p. 2, table A

3. Low winter flow releases – *Stream Management*
   Order 98-05 order 2.b.

4. Annual operations plan – *Stream Management*
   Order 98-05 order 3; GLOMP p. 103, 104

5. Notification of failure to meet required flows – *Stream Management*
   Order 98-05 order 3

6. Grant operations and storage targets – *Stream Management*
   Order 98-05 order 1.a.; Decision 1631 order 1; GLOMP p. 84

7. Amount and pattern of export releases to the Upper Owens River – *Stream Management*
   Order 98-05 order 2; Decision 1631 order 7; GLOMP p. 84, 85

8. Diversion targets from streams – *Stream Management*
Order 98-05 order 2; GLOMP p. 85

9. Export amounts dependent on Mono Lake level – *Stream Management*
Decision 1631 order 6

10. Year type designation and guidelines – *Stream Management*
Order 98-05 order 2; Decision 1631 order 3; GLOMP p. 87-96

11. Dry and wet cycle contingencies for stream restoration flows and base flows – *Stream Management*
Order 98-05 order 2; GLOMP p. 97

12. Deviations from Grant Lake Operation Management Plan (GLOMP) – *Stream Management*
Order 98-05 order 2; GLOMP p. 98, 99

13. Ramping rates – *Stream Management*
Order 98-05 order 2; Decision 1631 order 2; GLOMP p. 90-96

14. Stream restoration flows and channel maintenance flows – *Stream Management*
Order 98-05 order 1.a.

15. Salt Cedar eradication – *Waterfowl*
Order 98-05 order 4.e.; Waterfowl Plan p. 27

16. Aerial photography every five years or following an extreme wet year event – *Monitoring*
Order 98-05 order 1.b; Stream Plan p. 103

17. Make basic data available to public – *Monitoring*
Order 98-05 order 1.b as revised by Order 98-07; Order 98-07 order 1.b(2); Stream Plan p. 110

18. Operation of Lee Vining sediment bypass – Stream Facility Modifications
Order 98-05 order 2

19. Operation of the Rush Creek augmentation from the Lee Vining Conduit when necessary – *Stream Management*
Order 98-05 order 2

20. Make data from all existing Mono Basin data collection facilities available on an internet web site on a same-day basis – *Stream Management*
Order 98-05 order 2.c

Category B – Completed Items

1. Placement by helicopters of large woody debris into Rush Creek, completed fall 1999 – *Stream Work*
   Order 98-05 order 1; order 1.d.; Stream Plan p. 67, 68

2. Placement by helicopters of large woody debris into Lee Vining Creek, completed fall 1999 – *Stream Work*
   Order 98-05 order 1; order 1.d.; Stream Plan p. 67, 68

3. Rewater Rush Creek side channels in reach 3A, completed fall 1999 – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 68-71

4. Rewater Rush Creek side channel in reach 3B, completed fall 1999 with changes (see LADWP annual Compliance Reporting, May 2000) – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 68-71

5. Rewater Rush Creek side channel in reach 3D, completed fall 2002 with changes (see LADWP annual Compliance Reporting, May 2003) – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 68-71

6. Revegetate approximately 250 Jeffrey Pine trees on Lee Vining Creek, completed in 2000 – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 71-75

7. Revegetate willows on Walker Creek. No planting necessary in judgment of LADWP and MLC as area revegetated rapidly without intervention – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 71-75

8. Revegetate willows on Parker Creek. No planting necessary in judgment of LADWP and MLC as area revegetated rapidly without intervention – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 71-75

9. Limitations on vehicular access in Rush and Lee Vining Creek floodplains, completed fall 2003 – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 78-80

10. Removal of bags of spawning gravel, completed fall 2003 – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 85, 86

11. Removal of limiter logs, completed 1996 – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 86

12. Removal of Parker Plug, completed by California Department of Transportation 2000 – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 87

13. Sediment bypass facility for Lee Vining Creek, completed winter 2005 – *Stream Facility Modifications*
    Order 98-05 order 1.f.

14. Flood flow contingency measures, completed by California Department of Transportation's Highway 395 improvements in 2002 – *Stream Management*
    Order 98-05 order 1; Stream Plan p. 76

15. Stream monitoring site selection, completed 1997 – *Monitoring*
    Order 98-05 order 2; Stream Plan p. 109

16. Waterfowl and limnology consultants, completed 2004 – *Monitoring*
    Order 98-05 order 4; Waterfowl Plan p. 27-29

17. Status report on interim restoration in Mono Basin, completed 2006 – *Other*
    Decision 1631 order 8.d (3)

18. Cultural resources investigation and treatment plan report to SWRCB, completed 1996 – *Other*
    Decision 1631 order 9, 10

19. Revegetate or assess the need to revegetate Rush Creek side channels in reach 3A five years after rewatering, assessed annually and reported in May 2006 Monitoring Report – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 71-75

20. Revegetate or assess the need to revegetate Rush Creek side channels in reach 3B five years after rewatering, assessed annually and reported in May 2006 Monitoring Report – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 71-75

21. Revegetate or assess the need to revegetate Rush Creek side channel in reach 3D and reported in May 2008 Monitoring Report – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 71-75

22. Rewater Rush Creek side channel 11 in reach 4C. Final review was conducted by the Stream Scientists. After presentation of the final review, LADWP followed the recommendations of the Stream Scientists not to do any action on the channel. This item is now approved by SWRCB and is therefore considered completed in 2008. – *Waterfowl*
    Order 98-05 order 4.a., order 4.d.; Waterfowl Plan p. 22

23. Rewater Rush Creek side channel 14 in reach 4C. Final review was conducted by the Stream Scientists. After presentation of the final review, LADWP followed the recommendations of the Stream Scientists not to do any action on the channel. This item is now approved by SWRCB and is therefore considered complete in 2008. – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 68-71

24. Revegetate or assess the need to revegetate Rush Creek side channel 11 in reach 4C for five years following rewatering. LADWP followed the recommendations of the Stream Scientists not to do any action on the channel. This item is now approved by SWRCB and is therefore considered completed in 2008. – *Waterfowl Order 98-05 order 4.a., order 4.d.; Waterfowl Plan p. 22*

25. Revegetate or assess the need to revegetate Rush Creek side channel 14 in reach 4C for five years after rewatering. LADWP followed the recommendations of the Stream Scientists not to do any action on the channel. This item is now approved by SWRCB and is therefore considered completed in 2008. – *Stream Work Order 98-05 order 1; Stream Plan p. 68-71*

26. LADWP and MLC were to cooperatively revegetate pine trees on areas of Rush Creek and Lee Vining Creek including disturbed, interfluve, and upper terrace sites targeted from reach 3B through 5A on Rush Creek. In 2005, remaining suitable areas were assessed resulting in a map showing those areas where planting pine trees may be successful and would add to habitat complexity. LADWP and MLC investigated locations suitable for planting by LADWP and MLC staff and volunteers. Acceptable Jeffrey Pine seedlings were procured by LADWP and were planted by MLC and volunteers on all available suitable sites. This item is considered complete and is moved to Category B "Completed Items." However, MLC may continue to water these seedlings. MLC may also plant cottonwoods with volunteers as opportunities arise – Stream Work Order 98-05 order 1; Stream Plan p. 71-75

27. Rewater Rush Creek side channel 8 in reach 4B, completed March 2007 – *Waterfowl.* The further rewatering of Rush Creek side channel complex 8 in reach 4B was deferred by the Stream Scientists. Final review is being conducted by McBain and Trush. After presentation of the final review, LADWP followed the recommendations of the Stream Scientists and SWRCB has approved the plan *Order 98-05 order 4.a., order 4.d; Waterfowl Plan p. 22*

28. Rehabilitation of the Rush Creek Return Ditch, completed 2002 – *Stream Facility Modifications.* Since then, vegetation growth has slightly reduced ditch capacity. To restore maximum capacity of 380 cfs, the return ditch embankments were raised.
Order 98-05 order 1, order 1.c.; Stream Plan p. 85, appendix III

<u>Category C – In-Progress Items</u>

1. Placement by hand crews of large woody debris into Rush Creek on an opportunistic basis based on stream monitoring team recommendations – *Stream Work Order 98-05 order 1; order 1.d.; Stream Plan p. 67, 68*

2. Placement by hand crews of large woody debris into Lee Vining Creek on an opportunistic basis based on stream monitoring team recommendations – *Stream Work*

Order 98-05 order 1; order 1.d.; Stream Plan p. 67, 68

3. Grazing moratorium for 10 years, assessed annually and status reported in May 2009 Monitoring Report. Grazing moratorium to continue until further notice. – *Stream Management*
   Order 98-05 order 1; Stream Plan p. 83

4. Grant Lake Operation Management Plan (GLOMP) preparation for revisions – *Stream Management*
   Order 98-05 order 2; GLOMP p. 103, 104

5. Waterfowl project funding – *Waterfowl*
   Order 98-05 order 4.b.

6. Salt Cedar eradication reporting– *Waterfowl*
   Order 98-05 order 4.e.; Waterfowl Plan p. 27

7. Stream monitoring team to perform duties – *Monitoring*
   Order 98-05 order 1.b as revised by Order 98-07

8. Stream monitoring reporting to the SWRCB – *Monitoring*
   Order 98-05 order 1.b as revised by Order 98-07; Order 98-07 order 1.b(2); Stream Plan p. 110

9. Development, approval, and finalization of stream monitoring termination criteria for Walker and Parker Creeks – *Monitoring Order 98-07*

10. Development, approval, and finalization of stream monitoring termination criteria for Lee Vining and Rush Creeks – *Monitoring*
    Order 98-07

11. Hydrology monitoring and reporting – *Monitoring*
    Order 98-05 order 4; Waterfowl Plan p. 27

12. Lake limnology and secondary producers monitoring and reporting – *Monitoring*
    Order 98-05 order 4; Waterfowl Plan p. 27, 28

13. Riparian and Lake fringing wetland vegetation monitoring and reporting – *Monitoring*
    Order 98-05 order 4; Waterfowl Plan p. 27, 28

14. Waterfowl monitoring and reporting – *Monitoring*
    Order 98-05 order 4; Waterfowl Plan p. 28; LADWP's 2004 "Mono Lake Waterfowl Population Monitoring Protocol" submitted to SWRCB on October 6, 2004

15. Testing the physical capability for Rush Creek augmentation up to 150 cfs from the Lee Vining Conduit through the 5-Siphon Bypass facility – *Stream Management*
    Order 98-05 order 2; GLOMP p. 82, 83

16. Evaluation of the effects on Lee Vining Creek of Rush Creek augmentation for diversions up to 150 cfs through the Lee Vining Conduit – *Monitoring Order 98-05 order 1.b.*

17. Sediment bypass for Parker Creek – *Stream Facility Modifications Order 98-05 order 1.f.*

18. Sediment bypass for Walker Creek – *Stream Facility Modifications Order 98-05 order 1.f.*

Category D – Incomplete Items

None

Category E – Deferred Items

1. Recommend an Arizona Crossing or a complete road closure at the County Road Lee Vining Creek, if and when Mono County plans to take action – *Stream Work Order 98-05 order 1; Stream Plan p. 78-80*

2. Fish screens on all irrigation diversions – *Stream Facility Modifications Order 98-05 order 1; Stream Plan p. 84*

3. Prescribed burn program – *Waterfowl Order 98-05 order 4.b.(3)c.; Waterfowl Plan p. 25, 26*

4. Rewatering of Rush Creek side channel 1A in reach 4A.– *Stream Work Order 98-05 order 1; Stream Plan p. 68-71*

5. Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 1A in reach 4A – *Stream Work; Order 98-05 order 1; Stream Plan p. 68-71*

6. Rewater Rush Creek side channel 4Bii in reach 4B, completed March 2007 – Stream Work Order 98-05 order 1; Stream Plan p. 68-71

7. Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 4Bii in reach 4B. – Stream Work Order 98-05 order 1; Stream Plan p. 68-71

8. Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 8 in reach 4B.

9. Stream monitoring for 8-10 years to inform peak flow evaluation and recommendations including the need for a Grant Lake Reservoir Outlet – *Monitoring Order 98-05 order 1.b as revised by Order 98-07*

6. Completion Plans:

The following descriptions detail how LADWP plans to fulfill SWRCB requirements in the Mono Basin for each item above not categorized as complete or ongoing. This section will be reviewed annually by LADWP for revisions to reflect progress towards completion.

Category C – In-Progress Items

Item C1 – During walking surveys, large woody debris will be placed into Rush Creek and will continue to be done on an opportunistic basis based on recommendations made by the Monitoring Team. This item will remain "In-Progress" until the Monitoring Team indicates that no further work is required. At that time, this item will be considered complete and will be moved to Category B "Completed Items".

Item C2 – During walking surveys, large woody debris will be placed into Lee Vining Creek and will continue to be done on an opportunistic basis based on recommendations made by the Monitoring Team. This item will remain "In-Progress" until the Monitoring Team indicates that no further work is required. At that time, this item will be considered complete and will be moved to Category B "Completed Items".

Item C3 – The grazing moratorium in the Mono Basin was in effect until 2009. At this time LADWP does not intend to allow grazing on its lands in the Mono Basin and will continue the moratorium in 2016. This item will remain in the Category C "In Progress".

Item C4 – The Grant Lake Operation Management Plan (GLOMP) includes instructions to "review for revisions" every five years until Mono Lake reaches 6,391 feet above mean sea level. Although no revisions have been finalized to date, the plan was continuously under review. GLOMP is expected to be revised and replaced with "Mono Basin Operations Plan" (MBOP) after the SWRCB amends LADWP Water Rights licenses. This item will remain in Category C "In-Progress Items" until the final operation/management plan is approved by SWRCB. It is expected that a final plan will be developed after the Water Board order. Once the plan is approved, this item will be considered complete and will be moved to Category B "Completed Items".

Item C5 – LADWP is to make available a total of $275,000 for waterfowl restoration activities in the Mono Basin. This money was to be used by the USFS if they requested the funds by December 31, 2004. Afterwards, any remaining funds are to be made available to any party wishing to do waterfowl restoration in the Mono Basin after SWRCB review. USFS has requested funds for a project estimated at $100,000. MLC has requested that the remainder of the funds be applied toward the total cost of the Mill Creek Return Ditch upgrade which would provide benefits for waterfowl habitat. The Mill Creek Return Ditch rehabilitation is a component of a Federal Energy Regulatory Commission (FERC) settlement agreement. These funds will continue to be budgeted by LADWP until such a time that they have been utilized. Currently, this money has been tentatively been included in the Settlement Agreement as part of Administrative of Monitoring Accounts to be administered by a Monitoring Administration Team (MAT). Once the full $275,000 has been utilized, this item will be considered complete and will be moved to Category B "Completed Items".

Item C6 – Progress of the salt cedar eradication efforts is reported in the annual reports following the vegetation monitoring efforts. This was reported in the May 2010 Monitoring Report. This item will continue to be in progress until notice from SWRCB is received that LADWP's obligation for this in the Mono Basin is complete. Once this notice is received, this item will be moved to Category B "Completed Items".

Item C7 – The stream monitoring team continues to perform their required duties in the Mono Basin. This item will continue to be in progress until notice from SWRCB is received that LADWP's obligation for funding and managing the monitoring team in the Mono Basin is complete. Once this notice is received, this item will be moved to Category B "Completed Items", and LADWP will implement an appropriate monitoring program for the vegetation, stream morphology waterfowl, and fisheries.

Item C8 – Progress of the restoration efforts is reported in the annual reports. This item will continue to be in progress until notice from SWRCB is received that LADWP's obligation for this in the Mono Basin is complete. Once this notice is received, this item will be moved to Category B "Completed Items".

Item C9 – The Stream Scientists have submitted final recommendations for termination criteria on Walker and Parker Creeks in 2007 to the SWRCB. There has been no decision from SWRCB. Once the termination criteria are finalized by the Stream Scientists and approved by SWRCB, this item will be considered complete and will be moved to Category B "Completed Items".

Item C10 – The Stream Scientists have submitted final recommendations for termination criteria on Lee Vining and Rush Creeks in 2007 to the SWRCB. There has been no decision from SWRCB. Once approved by SWRCB, this item will be considered complete and will be moved to Category B "Completed Items".

Item C11 – LADWP will continue to monitor and report on the hydrology of the Mono Basin including regular Mono Lake elevation readings, stream flows, and spring surveys until SWRCB approves that all or portions of the hydrology monitoring is no longer required. Once this occurs, all or portions of this item will be considered complete and will be moved to Category B "Completed Items". Any portions of this requirement that are deemed to be ongoing by the SWRCB will be moved to Category A "Ongoing Items".

Item C12 – LADWP will continue to monitor and report on the Mono Lake limnology and secondary producers until SWRCB approves that limnological monitoring is no longer required. Once this occurs, this item will be considered complete and will be moved to Category B "Completed Items".

Item C13 – LADWP will continue to monitor and report on the vegetation status in riparian and lake fringing wetland habitats, which is done every 5 years until SWRCB approves that vegetation monitoring is no longer required. Once this occurs, this item will be considered complete and will be moved to Category B "Completed Items".

Item C14 – LADWP will continue to monitor and report on the waterfowl populations in the Mono Basin until SWRCB approves that waterfowl monitoring is no longer required. Once this occurs, this item will be considered complete and will be moved to Category B "Completed Items".

Item C15 – Testing augmentation of Rush Creek flows with water from Lee Vining Creek through the use of the Lee Vining Conduit is possible and can occur as needed as demonstrated during peak runoff in June 2005. The augmentation has been tested up to 100 cfs and the orders call for maximum augmentation to be 150 cfs. This will only be possible if adequate runoff is available in Lee Vining Creek after the peak operation is complete. Once augmentation is successfully tested through 150 cfs, this item will be moved to Category B "Completed Items".

Item C16 – Evaluation of the effects of Rush Creek augmentation on Lee Vining Creek needs to be completed to cover diversions up to 150 cfs. Once the evaluation is completed, this item will be moved to Category B "Completed Items".

Item C17 – Sediment bypass for Parker Creek is now in trial implementation stage. Once a plan is finalized by SWRCB and becomes part of LADWP's operation plans, this item will be moved to Category A "Ongoing Items".

Item C18 – Sediment bypass for Walker Creek is now in trial implementation stage. Once a plan is finalized by SWRCB and becomes part of LADWP's operation plans, this item will be moved to Category A "Ongoing Items".

Category D – Incomplete Items

None

Category E – Deferred Items

Item E1 – Pending further action by Mono County to improve the county road crossing at Lee Vining Creek, LADWP will write a letter to Mono County recommending an Arizona crossing at that point. Once LADWP writes this letter, or the parties agree that this is unnecessary; this item will be moved to Category B "Completed Items".

Item E2 – LADWP was to place fish screens on all of its irrigation diversions in the Mono Basin. Subsequently LADWP ended all irrigation practices and hence does not need to install fish screens. If at a later date LADWP resumes irrigation, fish screens will be installed and this item will be moved to Category A "Ongoing Items".

Item E3 – LADWP began a prescribed burn program with limited success. LADWP requested to remove this item from the requirements and the SWRCB instead ruled that the prescribed burn program will be deferred until Mono Lake reaches 6,391 ft. Once Mono Lake reaches 6,391 ft. LADWP will reassess the prescribed burn. Based on results from the assessment, LADWP will either reinstate the program or request relief from the SWRCB from this requirement. If LADWP reinstates the program this item will be moved to Category C "In-Progress Items", however if LADWP requests, and is granted relief from this SWRCB requirement, this item will be moved to Category B "Completed Items".

Item E4 - Rewatering of Rush Creek side channel 1A in reach 4A. Final review was conducted by the Stream Scientists. After presentation of the final review, LADWP followed the recommendations of the Stream Scientists not to do any action on the channel and was awaiting final decision by SWRCB. This item was approved by SWRCB and was therefore considered completed in 2008. Further work on Channel 1A was to be considered in the future if deemed appropriate. In 2014, as part of the pending new license, it has been included to be done in the future. Until the SWRCB approves the Settlement Agreement and amends LADWP's license, it will be placed in Category D – "Deferred Item".

Item E5 - Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 1A in reach 4A will occur for five years following rewatering. LADWP followed the recommendations of the Stream Scientists not to do any action on the channel and was awaiting final decision by SWRCB. This item was approved by SWRCB and was therefore considered completed in 2008. In 2014, as part of the pending new license, it has been included to be done in the future. Until the SWRCB approves the Settlement Agreement and amends LADWP's license, it will be placed in Category D – "Deferred Item".

Item E6 - Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 4Bii in reach 4B five years following rewatering (2007) occurred in the summer of 2012. The results from the assessment following the fifth year after rewatering was reported in Section 4 of the 2013 report. The final assessment concluded that satisfactory revegetation has occurred through natural processes and was considered complete and was moved to Category B "Completed Items". However, in 2014, as part of the pending new license, it has been included to be done in the future. Until the SWRCB approves the Settlement Agreement and amends LADWP's license, it will be placed in Category D – "Deferred Item".

Item E7 - Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 8 in reach 4B five years following rewatering (2007) occurred in the summer of 2012. The results from the assessment following the fifth year after rewatering were reported in Section 4 of the 2013 report. The final assessment concluded that satisfactory revegetation has occurred through natural processes and was considered complete and was moved to Category B "Completed Items". However, in 2014, as part of the pending new license, it has been included to be done in the future. Until the SWRCB approves the Settlement Agreement and amends LADWP's license, it will be placed in Category D – "Deferred Item".

Item E8 – The stream monitoring team is to evaluate the restoration program after "no less than 8 years and no more than 10 years" from the commencement of the restoration program. This evaluation is to cover the need for a Grant Lake outlet, Rush Creek augmentation, and the prescribed stream flow regime. According to SWRCB Order Nos. 98-05 and 98-07, evaluation of LADWP's facilities to adequately provide proper flows to Rush Creek "*shall take place after two data gathering cycles but no less than 8 years nor more than 10 years after the monitoring program begins*". The Monitoring Team submitted final recommendation, on April 30, 2010. LADWP had 120 days after receiving the recommendation from the monitoring team to determine whether to implement the recommendation of the monitoring team. On July 28, 2010, LADWP submitted a Feasibility Report evaluating the recommendations. In September 2013, LADWP entered into a Settlement Agreement with the Stakeholders and this Agreement is pending SWRCB's approval via an amended Water Rights license. Until the SWRCB approves the Settlement Agreement and amends LADWP's license, it will be placed in Category D – "Deferred Item".

7. Ongoing Items Description:

See Section 5 for references where each requirement originates.

Category A – Ongoing Items

Item A1 – *Road closures*. Periodically LADWP personnel will visit all road closures performed by LADWP in accordance with SWRCB Order No. 98-05, Order 1, in the Lower Rush and Lee Vining Creek areas to assess their effectiveness. Where evidence exists that a road closure is ineffective, LADWP will improve the road closures through means such as additional barriers.

Item A2 – *Base flow releases*. LADWP normally will control flow releases from its facilities into Lower Rush, Parker, Walker, and Lee Vining Creeks according to agreed upon flow rate requirements as set forth in the SWRCB Decision 1631, Order Nos. 98-05 and Order 98-07, the Grant Lake Operations Management Plan, and any subsequent operations plans and decisions made by the SWRCB.

Item A3 – *Low winter flow releases*. Per the California Department of Fish and Wildlife recommendations, and SWRCB Order No. 98-05, order 2.b., LADWP will maintain winter flows into Lower Rush Creek below 70 cfs in order to avoid harming the Rush Creek fishery.

Item A4 – *Annual operations plan*. Per SWRCB Order No. 98-05, order 3, LADWP will distribute an annual operations plan covering its proposed water diversions and releases in the Mono Basin. Presently the requirement is to distribute this plan to the SWRCB and all interested parties by May 15 of each year.

Item A5 – *Notification of failure to meet flow requirements*. Per SWRCB Order No. 98-05, order 3, and SWRCB Decision 1631, order 4, if at the beginning of the runoff year, for any reason, LADWP believes it cannot meet SWRCB flow requirements, LADWP will provide a written explanation to the Chief of the Division of Water Rights by May 1, along with an explanation of the flows that will be provided. If unanticipated events prevent LADWP from meeting SWRCB Order No. 98-05 Stream Restoration Flow requirements, LADWP will notify the Chief of the Division of Water Rights within 20 days and provide a written explanation of why the requirement was not met. LADWP will provide 72 hours notice and an explanation as soon as reasonably possible for violation of SWRCB Decision 1631 minimum instream flow requirements.

Item A6 – *Grant storage targets*. LADWP will operate its Mono Basin facilities to maintain a target storage elevation in Grant Lake Reservoir between 30,000 and 35,000 acre-feet at the beginning and end of the runoff year. LADWP shall seek to have 40,000 acre-feet in Grant Reservoir on April 1 each year at the beginning of wet and extreme wet years.

Item A7 – *Export release patterns to the Upper Owens River*. Per SWRCB Decision 1631, order 7, and SWRCB Order No. 98-05, order 2, LADWP will make exports from the Mono Basin to the Upper Owens River in a manner that will not have a combined flow rate below East Portal above 250 cfs. LADWP will perform ramping of exports at 20% or 10 cfs, whichever is greater, on the ascending limb, and 10% or 10 cfs, whichever is greater, on the descending limb of the hydrograph as measured at the Upper Owens River.

Item A8 – *Diversion targets from streams*. Per the 1996 GLOMP, diversion targets for exports from the Mono Basin will be divided between Rush, Lee Vining, Parker and Walker Creeks in the following manner. During all years except dry and extremely wet years, LADWP will seek to divert one-third to one-half of the export amount from Lee Vining Creek, with the remaining water coming from Rush Creek. Only during dry years when 16,000 acre-feet of export is permitted, LADWP will seek to divert from Parker and Walker Creeks. During extremely wet years, all exports will come from diversions off of Rush Creek. Parker and Walker Creeks are expected to be flow through after the SWRCB approves the Settlement Agreement and amends LADWP Water Rights licenses.

Item A9 – *Export amounts dependent on Mono Lake level*. LADWP export amounts follow those ordered by SWRCB Decision 1631, order 2.

Item A10 – *Year type designation and guidelines*. Per SWRCB Decision 1631, order 4, SWRCB Order No. 98-05, and GLOMP, LADWP will perform runoff year forecasts for the Mono Basin with preliminary forecasts being conducted on February 1, March 1, and April 1, with the forecast being finalized on or around May 1 if necessary. LADWP developed a draft May 1 forecast methodology without a need for May snow surveys. When Gem Pass snow pillow measures show an increase in water content between April 1 and May 1, the percentage change experienced by the pillow will be applied to all of the April 1st snow course survey measurements used in calculating the runoff. A slight adjustment to the calculation may be made for dry years. Additionally, the May 1st forecast will have measured April values.

Item A11 – *Dry and wet cycle contingencies for stream restoration flows and base flows*. During consecutive dry years LADWP will release channel maintenance flows (CMF) every other year. The CMF will commence in the second consecutive dry year The channel maintenance flows for Rush Creek will be 100 cfs for five days, and for Lee Vining Creek it will be 75 cfs for five days. Ramping rates will be 10 cfs per day. The occurrence of a year type other than a dry year will terminate the dry year cycle. During consecutive wet years, LADWP will increase base flows above the minimum flow rate every other year. The increased base flows will commence in the second consecutive wet year. The occurrence of a year type other than a wet year will terminate the wet year cycle.

Item A12 – *Deviations from Grant Lake Operation Management Plan (GLOMP)*. LADWP must maintain operational flexibility to adjust or react to unpredictable circumstances.

Item A13 – *Ramping rates*. LADWP will continue to operate its Mono Basin facilities in order to provide SWRCB ramping flow requirements for Lee Vining, Parker, Walker, and Rush Creeks.

Item A14 – *Stream restoration flows and channel maintenance flows*. LADWP will continue to operate its Mono Basin facilities in order to provide peak flow requirements for Lee Vining, Parker, Walker, and Rush Creeks.

Item A15 – *Salt Cedar eradication*. LADWP will continue assisting in a Mono Basin wide effort to eradicate Salt Cedar (*Tamarisk*), and will continue to report on these efforts.

Item A16 – *Aerial Photography.* LADWP will capture aerial and/or satellite imagery of the Mono Basin (Stream Plan, 1" = 6,000' scale; SWRCB Order No. 98-05, Section 6.4.6(4), 1:6,000 scale) every five years or following an extreme wet year event, which resets the five year clock.

Item A17 – *Make basic data available to public*. Per SWRCB Order 98-05, Order 1.b., as revised by SWRCB Order No. 98-07, order 1.b(2), LADWP will continue to make all basic monitoring data available to the public.

Item A18 – *Operation of Lee Vining sediment bypass*. In order to bypass sediment past the Lee Vining diversion facility, LADWP will operate the Lee Vining Conduit control gate to assist with ramping flows towards peak with the intention of having it be in the completely open position while peak flows are passing the diversion facility. After peak flows have passed the facility, the Lee Vining Conduit control gate will slowly close assisting with ramping flows back down towards base flow condition.

Item A19 – *Operation of the Rush Creek augmentation from the Lee Vining Conduit when necessary*. At times when peak flow requirements in Rush Creek exceed facility capacities, and Grant Lake Reservoir is not spilling, LADWP will operate the Lee Vining Conduit 5-Siphon Bypass to bring water from Lee Vining Creek to Rush Creek to augment flows to the required levels.

Item A20 – Data from existing Mono Basin data collection facilities is available on a same-day basis on the LADWP.com internet web site. The data collection and reporting works, as with any other system, can experience periodic short term communication problems and/or technical difficulties, which may result in incorrect readings. LADWP will continue to monitor the data posting on a daily basis and will work to troubleshoot and correct problems as soon as possible. LADWP will continue to improve the data collection, computer, and communication systems as new technology(ies) become available.

Section 2

Mono Basin Operations

Section 2

Mono Basin Operations

Compliance with State Water Resources Control Board Decision 1631 and Order Nos. 98-05 and 98-07

May 2016

Los Angeles Department of Water and Power

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I. Introduction

Pursuant to State Water Resources Control Board (SWRCB) Decision 1631 and Order Nos. 98-05 and 98-07 (Orders), the Los Angeles Department of Water and Power (LADWP) undertakes certain activities in the Mono Basin in compliance with the terms and conditions of its water right licenses 10191 and 10192. In addition to restoration and monitoring activities covered in this report, LADWP also reports on certain required operational activities.

II. Summary of Mono Basin RY 2015-16 Operations

A. Rush Creek

The runoff from Rush Creek was approximately 25,039 AF which amounts to the total water delivered to GLR's 'Damsite'. The highest flow of 115 cfs occurred on March 30, 2016.

Rush Creek flows below 'the Narrows', which consist of Rush Creek releases (Return Ditch, Spill, and 5-Siphons augmentation) combined with Parker and Walker Creek flows, had an approximate total of 30,041 AF. This flow terminated into Mono Lake.

RY 2015 was forecasted as a Dry year type and as such, following Guideline 'A', there was no peak flow released.

1. Rush Creek Augmentation

To meet high flow targets for lower Rush Creek, LADWP at times must employ facilities in addition to the Mono Gate One Return Ditch (MGORD) which has a 380 cfs capacity limit. During wetter years, LADWP utilizes one or both of its additional facilities to release higher peak flows. These facilities include the 5-Siphons bypass, which can release up to 100 cfs from Lee Vining Creek, and the GLR Spillway which can release large reservoir spills into lower Rush Creek during the wetter years.

<u>5-Siphons Bypass</u>
RY 2015 was forecasted as a Dry year type and as such, following Guideline 'A', there was no peak flow released in Rush Creek and therefore 5-Siphons were not utilized.

<u>Grant Reservoir Spill</u>
Grant did not spill during RY 2015.

B. Lee Vining Creek

RY 2015 was forecasted as a Dry year type and as such, following Guideline 'A', there was no 'pass the peak' operation.

Lee Vining Creek had its highest flow on June 2, 2015 at 104 cfs. Total runoff for the year was approximately 23,061 AF.

C. Dry Cycle Channel Maintenance Flows

RY2015 was the fourth consecutive dry year, therefore dry cycle channel maintenance flows (CMF) should be released in accordance with the GLOMP (for Rush Creek, if Grant Lake Reservoir storage stays above 11,500 AF). However on May 1, 2015 the parties (MLC, CalTrout, CDFW) and the Stream Scientists requested the CMF not be released on Rush Creek or Lee Vining Creek during the runoff year. LADWP honored the request.

D. Parker and Walker Creeks

Parker and Walker were operated as pass through for RY2015.

Parker Creek had its highest flow on June 14, 2015 at 31 cfs. Total runoff for the year was approximately 4,371 AF.

Walker Creek had its highest flow on June 1, 2015 at 19 cfs. Total runoff for the year was approximately 2,615 AF.

E. Grant Lake Reservoir

Grant Lake began the runoff year at approximately 15,556 AF (7,095.3 ft AMSL). The reservoir did not spill during the RY. Final storage volume by the end of the RY of March 31, 2016 was approximately 15,991 AF (7,096.0 ft AMSL).

F. Exports during RY 2015-16

During RY2015, Mono Lake elevations were within the 6,377 ft – 6,380 ft range, allowing for up to 4,500 AF of exports per D1631. LADWP exported 4,417 AF total from the Mono Basin, which is slightly below the allowed 4,500 AF.

G. Mono Lake Elevations during RY 2015-16

In RY2015, Mono Lake elevations were as shown in the following table. The Lake elevation was at 6,379.02 ft AMSL at the beginning of the runoff year, and ended the runoff year at 6,378.11 ft AMSL, a decrease of 0.91 ft.

RY 2015-16 Mono Lake Elevation Readings

April 1, 2015	6,379.02
May 1, 2015	6,378.92
June 1, 2015	6,379.13
July 1, 2015	6,379.02
August 1, 2015	6,378.80
September 1, 2015	6,378.46
October 1, 2015	6,378.20
November 1, 2015	6,378.10
December 1, 2015	6,377.95
January 1, 2016	6,377.90

February 1, 2016	6,378.06
March 1, 2016	6,378.10
April 1, 2016	6,378.11

III. Proposed Mono Basin Operations Plan RY 2016-17

A. Forecast for RY 2016-17

The Mono Basin's April 1st forecast for Runoff Year (RY) 2016 for April to March period is 90,100 acre-feet (AF), or 74 percent of average using the 1961-2010 long term mean of 122,333 AF (**Attachment 2**). This value puts the year type within the 'Dry-Normal I' category. According to the Grant Lake Operations Management Plan (GLOMP) approved under SWRCB Order 98-05, LADWP will follow Guideline 'B' (**Attachment 3**) and as specified below for the operation requirements during RY 2016.

B. Rush Creek

1. Rush Creek Base Flow

Base flows will follow Guideline 'B' of 47 cubic feet per second (cfs) from April 1 to September 30, 2016, and 44 cfs from October 1, 2016 to March 31, 2017. If Grant Lake inflow is less than the dry year base flow and/or if Grant Lake storage drops below 11,500 AF, base flow requirements for a dry year under Guideline A applies.

2. Rush Creek Peak Flow

Peak flows will follow Guideline 'B' of 200 cubic feet per second (cfs) for 7 days. Peak flow operations may be reduced or eliminated if Grant Lake storage drops below 11,500 AF in accordance with Section 1.a.(1) of Order 98-05. The expected magnitude and timing of the peak flows in Rush Creek were generated by the Mono Basin Operations Model (MBOM), the results of which are shown below:

Predicted magnitude and timing of peak flows		
Creek	**Magnitude**	**Timing**
Rush	231 cfs	May 26, 2016

3. Rush Creek Augmentation

In wetter years where peak flow requirements may exceed the Mono Gate One Return Ditch (MGORD) or Grant Outlet pipe maximum design capacities, LADWP utilizes one or both of its additional facilities to release the higher peak flows. These facilities include the 5-Siphons bypass, which can release as tested 100 cfs from Lee Vining Creek, and the GLR Spillway, which can release large reservoir spills into lower Rush Creek during the wetter years. However, for RY2016 the 5-Siphons Bypass will not be needed and Grant Lake Reservoir is not forecasted to spill.

C. Lee Vining Creek

1. Lee Vining Creek Base Flow

Base flows will follow Guideline 'B' of 54 cfs, or flow at Lee Vining Creek 'Above', whichever is less, from April 1 to September 30, 2016, and 40 cfs, or Lee Vining Creek 'Above', whichever is less, from October 1, 2016 to March 31, 2017. All flows in excess of these requirements will be diverted to Grant Lake Reservoir through the Lee Vining Conduit.

2. Lee Vining Creek Peak Flow

Peak flows will be allowed to pass through the diversion facility per Guideline 'B'. Peak flow operations may be reduced or eliminated if Grant Lake storage drops below 11,500 AF in accordance with Section 1.a.(1) of Order 98-05. The expected magnitude and timing of the peak flows in Lee Vining Creek were generated by the Mono Basin Operations Model (MBOM), the results of which are shown below:

Predicted magnitude and timing of peak flows		
Creek	**Magnitude**	**Timing**
Lee Vining	215 cfs	May 17, 2016

D. Dry Cycle Channel Maintenance Flows

Because RY2016 is forecasted to be a Dry-Normal I year, dry cycle channel maintenance flows will not be required in accordance with the GLOMP.

E. Parker and Walker Creeks

Parker and Walker Creek facilities will be operated as pass through in accordance with Guideline 'B'.

F. Grant Lake Reservoir

Grant Lake Reservoir (GLR) storage volume was 15,991 AF, corresponding to a surface elevation of 7,096.0 feet above mean sea level (AMSL) at the start of the runoff year. Using the closest available representative historical inflow data (2001 runoff year at 75 percent of normal), and Guideline 'B' base flows, GLR is projected as shown in **Attachment 4**. Forecasted scenarios will be relatively close only if this year's hydrology turns out to be similar to the hydrology of the selected historical runoff year. Operations are subject to change with variations in actual hydrology during the upcoming runoff year.

G. Planned Exports for RY 2016-17

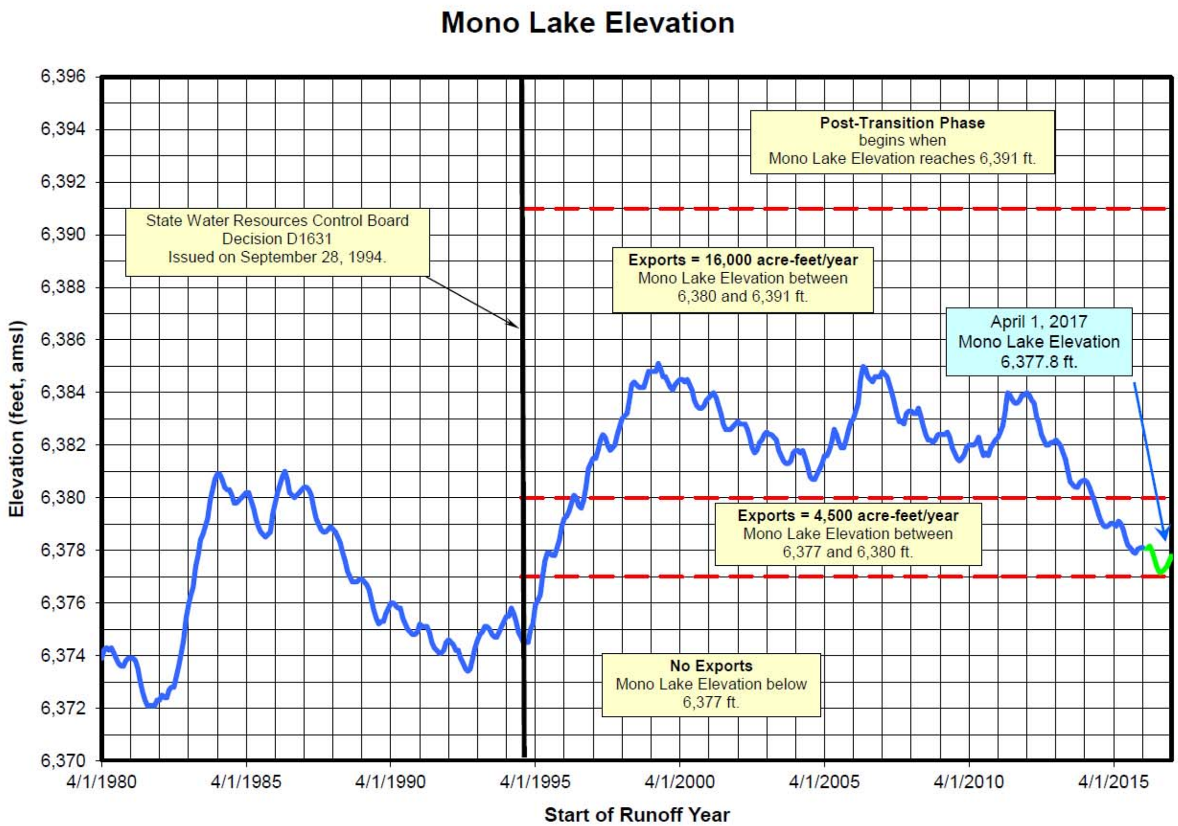
Mono Lake elevations are expected to remain within the 6,377 ft – 6,380 ft range, which allows for 4,500 AF of exports per the SWRCB Decision 1631. LADWP plans to conduct export operations in the later part of the runoff year.

H. Expected Mono Lake Elevations during RY 2016-17

Mono Lake began this runoff year at 6,378.11 ft AMSL where it is forecasted to decrease and end the runoff year at approximately 6,377.8 ft AMSL (**Attachment 1**).

ATTACHMENTS

Attachment 1



Attachment 2

2016 EASTERN SIERRA RUNOFF FORECAST
April 1, 2016

APRIL THROUGH SEPTEMBER RUNOFF

	MOST PROBABLE VALUE (Acre-feet)	MOST PROBABLE VALUE (% of Avg.)	REASONABLE MAXIMUM (% of Avg.)	REASONABLE MINIMUM (% of Avg.)	LONG-TERM MEAN (1961 - 2010) (Acre-feet)
MONO BASIN:	**73,000**	**71%**	83%	58%	103,522
OWENS RIVER BASIN:	**203,100**	**67%**	80%	54%	303,903

APRIL THROUGH MARCH RUNOFF

	MOST PROBABLE VALUE (Acre-feet)	MOST PROBABLE VALUE (% of Avg.)	REASONABLE MAXIMUM (% of Avg.)	REASONABLE MINIMUM (% of Avg.)	LONG-TERM MEAN (1961 - 2010) (Acre-feet)
MONO BASIN:	**90,100**	**74%**	87%	60%	122,333
OWENS RIVER BASIN:	**293,800**	**71%**	84%	59%	412,284

NOTE - Owens River Basin includes Long, Round and Owens Valleys (not incl Laws Area)

MOST PROBABLE - That runoff which is expected if median precipitation occurs after the forecast date.

REASONABLE MAXIMUM - That runoff which is expected to occur if precipitation subsequent to the forecast is equal to the amount which is exceeded on the average once in 10 years.

REASONABLE MINIMUM - That runoff which is expected to occur if precipitation subsequent to the forecast is equal to the amount which is exceeded on the average 9 out of 10 years.

Mono Basin Operations, Guideline B

Year Type……………………………………………………………………….DRY–NORMAL I
Forecasted Runoff in acre-feet...…………………………………………………..83,655 – 91,590

Lower Rush Creek

Base Flows:

	Apr–Sep	Oct-Mar
Flow (cfs)	47	44

Minimum base flows should equal the lesser of the inflow to Grant Lake or the minimum requirements listed above. However, if Grant Lake inflow is less than the dry year base flow requirements under Guideline A, dry year requirements apply. If Grant Lake storage drops below 11,500 acre-feet (7,089.4' elevation), base flow requirements for a dry-year under Guideline A also apply (D-1631, p 197-198).

Peak Flows: - 200 cfs for 7 days*.

Ramping:
- Begin ramping on May 15th (rule of thumb). Note that peak operations will take 32 days, so timing this with peak flows in P/W Creeks, with fish movement, and cottonwood germination is beneficial.
- 10 percent daily change during ascending and descending limbs, or 10-cfs, whichever is greater.

Lee Vining Creek

Base Flows:

	Apr–Sep	Oct-Mar
Flow (cfs)	54	40

Minimum base flows are those specified above or the stream flow at the point of diversion, whichever is less.

Peak Flows: - Allow peak flow to pass through diversion facility.

Ramping:
- Begin ramping on May 15th (rule of thumb).
- 20 percent daily change during ascending limb and 15 percent during descending limb, or 10-cfs change, whichever is greater.

Diversions:
- Divert flows in excess of base flows except during peak operations.
- Diversions may resume 7 days after peak flow (rule of thumb); divert flows in excess of base flow requirements.

Augmentation: - None

Parker and Walker Creeks

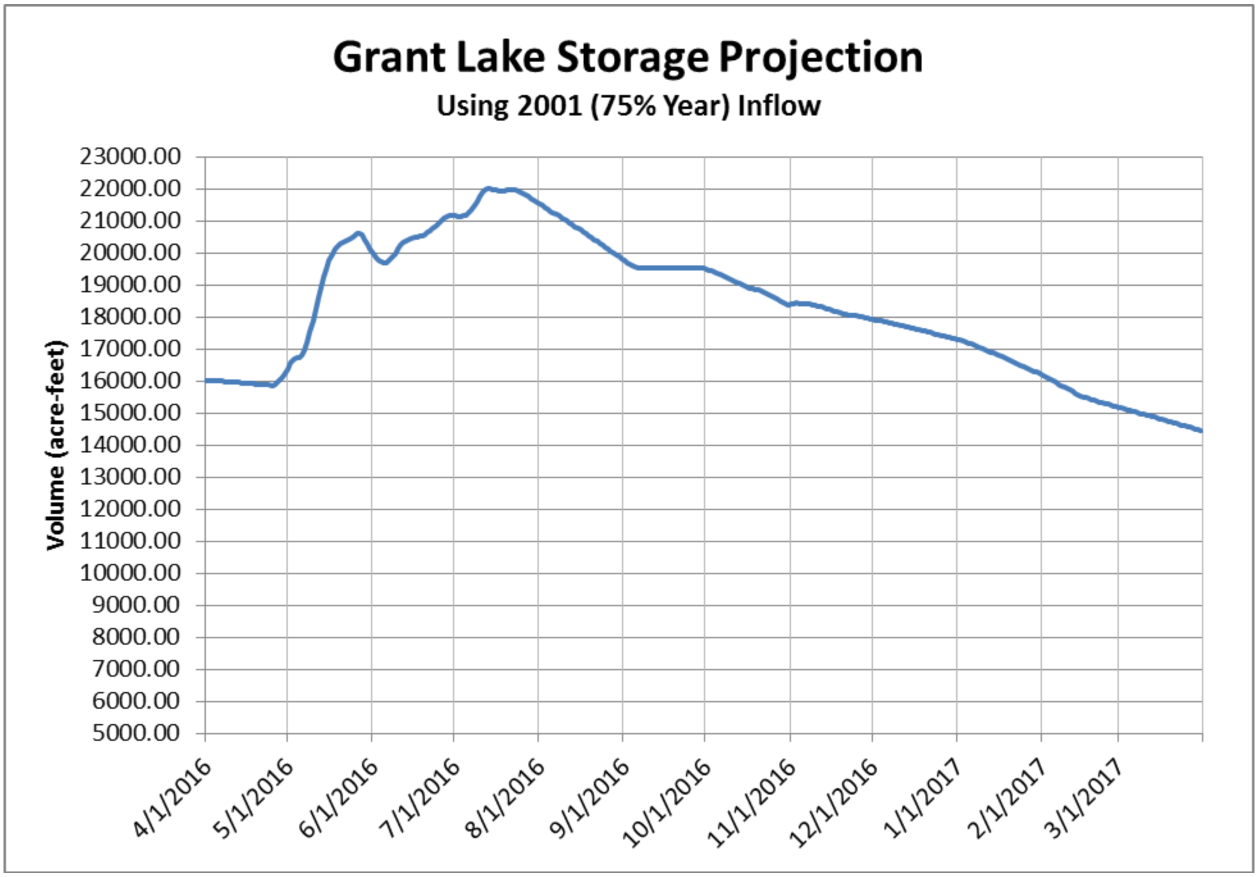
Flow-through conditions for entire year.

Exports

4,500 acre-feet scenario – Maintain 6 cfs export throughout the year.
16,000 acre-feet scenario – Maintain 22 cfs export throughout the year.

*Section 1. a. (1) of Order 98-05 states that LADWP may reduce SRF's in dry/normal and normal years to maintain exports allowed under D-1631; that LADWP will seek to have between 30,000 and 35,000 acre-feet (elev. 7,113' and 7,119') in Grant Lake at the beginning and end of each runoff season; and LADWP will not be required to reduce storage in Grant Lake below 11,500 acre-feet (elev. 7089.4') to provide SRFs.

RY 2016/17 Grant Lake Reservoir Storage Projection



Section 3

Fisheries Monitoring Report for Rush, Lee Vining, Parker, and Walker Creeks 2015-16

Mono Basin Fisheries Monitoring Report
Rush, Lee Vining, and Walker Creeks
2015

Prepared by Ross Taylor and Associates for
Los Angeles Department of Water and Power's Annual Compliance Report to the State Water Resources Control Board

Date: April 15, 2016

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Executive Summary

This report presents results of the nineteenth year of trout population monitoring for Rush, Lee Vining, and Walker Creeks pursuant to State Water Resources Control Board's (SWRCB) Water Right Decision 1631 (D1631) and the seventeenth year following SWRCB Orders #98-05 and #98-07. This report provides the trout population data collected between September 15th and 24th 2015 as mandated by the Orders and the Settlement Agreement.

As measured on April 1st, the 2015 runoff year (RY) was 25% of normal and classified a dry runoff year type. This was the fourth consecutive dry runoff year type (RY 2014 was 48% of normal, RY 2013 was 66% of normal and RY 2012 was 55% of normal). Annual electrofishing mark-recapture monitoring was conducted in two sections of Rush Creek and in the main channel section of Lee Vining Creek. Multiple-pass depletion electrofishing was conducted in the Lee Vining Creek side channel and in Walker Creek. These data were used to generate population estimates, density estimates, standing crop estimates, condition factors, relative stock densities, and growth rates from PIT tag recaptures. A single electrofishing pass was made through the MGORD section of Rush Creek to assess condition factors, relative stock densities, and growth rates from PIT tag recaptures.

Population Estimates

The Upper Rush section supported an estimated 647 age-0 brown trout in 2015 compared to 1,309 age-0 fish in 2014. This section supported an estimated 297 brown trout 125-199 mm in length in 2015 compared to 553 fish in 2014. In 2015, Upper Rush supported an estimated 117 brown trout ≥200 mm in length compared to an estimate of 105 fish in 2014. In 2015, two brown trout ≥300 mm in length were captured in the Upper Rush section; these fish were 400 and 480 mm in length.

The Bottomlands section supported an estimated 465 age-0 brown trout in 2015 versus 174 age-0 fish in 2014. This section supported an estimated 96 brown trout 125-199 mm in length in 2015 compared to 276 fish in 2014. The Bottomlands section supported an estimated 62 brown trout ≥200 mm in 2015 compared to 30 trout in 2014. In 2015, one brown trout ≥300 mm was captured in the Bottomlands section; this fish was 470 mm in length.

Lee Vining Creek's main channel section supported an estimated 251 age-0 brown trout in 2015, compared to an estimated 242 age-0 fish in 2014. This section supported an estimated 192 brown trout 125-199 mm in length in 2015 compared to 276 fish in 2014. Lee Vining Creek's main channel supported an estimated 55 brown ≥200 mm in 2015 (versus 34 fish in 2014).

A total of 20 rainbow trout were captured in Lee Vining Creek's main channel making up approximately 5% of the total trout catch in 2015. No age-0 rainbow trout (<125 mm) were captured during the 2015 sampling. The 2015 estimate for rainbow trout in the 125-199 mm size class was 12 fish versus estimates of 47 fish in. The 2015 estimate for rainbow trout ≥200 mm in length was nine fish versus estimates of 16 fish in 2014.

The 2015 age-0 brown trout estimate for Walker Creek was 112 fish, a 100% increase from the 2014 estimate of 56 fish. The 2015 population estimate for brown trout in the 125-199 mm size class was 59 trout. Brown trout ≥200 mm in length (19 fish) accounted for 10% of the total catch in 2015 and the population estimate for this size class was also 19 brown trout. The largest brown trout captured in Walker Creek in 2015 was 249 mm in length.

In the Lee Vining Creek side channel, seven brown trout were captured in two electrofishing passes during the 2015 sampling. No age-0 fish were captured; all seven fish were 125-199 mm in length and were caught on the first pass. The estimate for this size class was seven brown trout. No rainbow trout were captured in the side channel in 2015. This was the seventh consecutive year that no age-0 rainbow trout were captured in the Lee Vining Creek side channel and the fifth consecutive year the no age-1+ rainbows were captured.

Densities of Age-0 Trout

Age-0 brown trout density estimates (numbers per hectare) decreased in the Upper Rush section and increased Bottomlands section of Rush Creek in 2015 when compared to the 2014 values. In 2015, the Upper Rush section's estimated density of age-0 brown trout was 2,061 fish/ha and the Bottomlands section's estimated density of age-0 brown trout equaled 1,581 fish/ha. In Walker Creek, the 2015 density estimate of age-0 brown trout was 3,414 fish/ha. The 2015 age-0 brown trout density estimate in the main channel of Lee Vining Creek was 2,051 fish/ha. In 2015, no age-0 brown trout were captured in the Lee Vining Creek side channel, the second consecutive year that no age-0 brown trout were captured in the side channel.

In the Lee Vining Creek main channel, no age-0 rainbow trout were captured during the 2015 sampling. For the seventh consecutive year no age-0 rainbow trout were captured in the Lee Vining Creek side channel.

Densities of Age-1 and older (aka Age-1+) Trout

From 2014 to 2015, the Upper Rush section's estimated density of age-1+ trout/ha decreased by 38% and the Bottomlands section's estimated density of age-1+ trout/ha decreased by 46%. The 2015 density estimate of age-1+ brown trout/ha was the lowest since the start of sampling the Bottomlands section in 2008. The 2015 density estimate of age-1+ brown trout in the Walker Creek section experienced a 36% decrease from the 2014 estimate. In the Lee Vining Creek main channel section, the 2015 density estimate of age-1+ brown trout was a 10% decrease from the 2014 estimate.

In 2015, the Lee Vining Creek side channel's density estimate of age-1 and older brown trout/ha was 58% greater than the 2014 estimate; however this increased density estimate was solely a function of a large reduction of wetted surface area within the sample section.

For a fifth consecutive year no age-1 and older rainbow trout were captured in the Lee Vining Creek side channel. Estimated densities of age-1 and older rainbow trout in the Lee Vining Creek main channel decreased by 62% between 2014 and 2015.

Standing Crop Estimates

The estimated standing crop for brown trout in the Upper Rush section was 123 kg/ha in 2015. The estimated standing crop for brown trout in the Bottomlands section of Rush Creek was 59 kg/ha in 2015.

The estimated standing crop for brown trout in Walker Creek was 183 kg/ha in 2015. The 2015 standing crop estimate was the fourth highest value recorded in Walker Creek over the 17-year sample period.

The Lee Vining Creek main channel in 2015 produced a total estimated standing crop of 150 kg/ha for both rainbow and brown trout. The 2015 brown trout standing crop estimate was 138 kg/ha and the rainbow trout standing crop estimate was 12 kg/ha. Since 2013, the rainbow trout standing crop estimates in the Lee Vining Creek main channel have decreased by 75%.

The Lee Vining Creek side channel produced a brown trout standing crop estimate of 45 kg/ha in 2015. No rainbow trout were captured in the side channel in 2015 and none have been sampled in the side channel for five consecutive years (2011-2015).

Condition Factors

Condition factors of brown trout 150 to 250 mm in length in 2015 decreased in two sections (Upper Rush and Walker) from 2014's values, increased in three sections from 2014's values (MGORD, Lee Vining side channel, and Lee Vining main channel), and stayed the same in one section (Rush Bottomlands). In 2015, no sections had brown trout condition factors ≥1.00.

The Upper Rush section had a condition factor of 0.97 in 2015. The Bottomlands section had a condition factor of 0.96 in 2015. The MGORD's 2015 condition factor equalled 0.97.

For the third consecutive year, both brown trout and rainbow in Lee Vining Creek's main channel had a condition factor below 1.00. Rainbow trout (in 2015) once again had a better condition factor than the brown trout (0.98 versus 0.94) in the main channel section of Lee Vining Creek.

In 2015, brown trout in Lee Vining Creek's side channel had a condition factor 0.90. This was the third consecutive year in the 15 years of sampling the side channel that condition factors were less than 1.00.

In Walker Creek, brown trout had a condition factor of 0.98 in 2015, a slight decrease from 1.00 in 2014.

Relative Stock Densities (RSD)

In the Upper Rush section, the 2015 RSD-225 value of 15 was the first increase after four consecutive years of declining RSD-225 values. The RSD-300 value was 1 in 2015, which has not changed for the past five sampling years.

In the Bottomlands section of Rush Creek, the 2015 RSD-225 value increased to a value of 23, the second highest value for the eight sampling years. The RSD-300 value was 1 in 2015, based on the capture of a single brown trout ≥300 mm.

In the MGORD, the RSD-225 value increased from 53 in 2014 to 72 in 2015. In 2015, the RSD-300 value was 25, a more than three-fold increase from a value of 7 in 2014. The RSD-375 value in 2015 was 8, up from a value of 3 in 2014. The increased RSD-300 and RSD-375 values in 2015 were solely a function of the low numbers of trout ≥150 mm captured and do not reflect that more, larger fish, were present in the MGORD.

RSD values in Lee Vining Creek were generated for the main channel combined with the side channel and for the main channel only. Slightly greater numbers of trout ≥150 mm were captured in 2015, compared to 2014. However, fewer trout ≥225 mm captured in 2015 resulted in decreased RSD-225 values for the main/side combined and main channel only (9 in both sections) when compared to 2014's values.

Introduction

This report presents results of the nineteenth year of trout population monitoring for Rush, Lee Vining, and Walker Creeks pursuant to State Water Resources Control Board's (SWRCB) Water Right Decision 1631 (D1631) and the seventeenth year following SWRCB Orders #98-05 and #98-07. Order 98-07 stated that the monitoring team would develop and implement a means for counting or evaluating the number, weights, lengths and ages of trout present in various reaches of Rush Creek, Lee Vining Creek, Parker Creek and Walker Creek. This report provides trout population data collected in 2015 as mandated by the Orders and the Settlement Agreement.

Study Area

Between September 15th and 24th, 2015, Los Angeles Department of Water and Power (LADWP) staff and Ross Taylor, the SWRCB fisheries scientist, conducted the annual fisheries monitoring surveys in six reaches along Rush, Lee Vining, and Walker Creeks in the Mono Lake Basin. The County Road section of Rush Creek was dropped from the sampling regime in 2014. The six reaches were similar in length to those which have been sampled between 2009 and 2014 (Figure 1). Aerial photographs of the 2015 sampling reaches can be found in Appendix A.

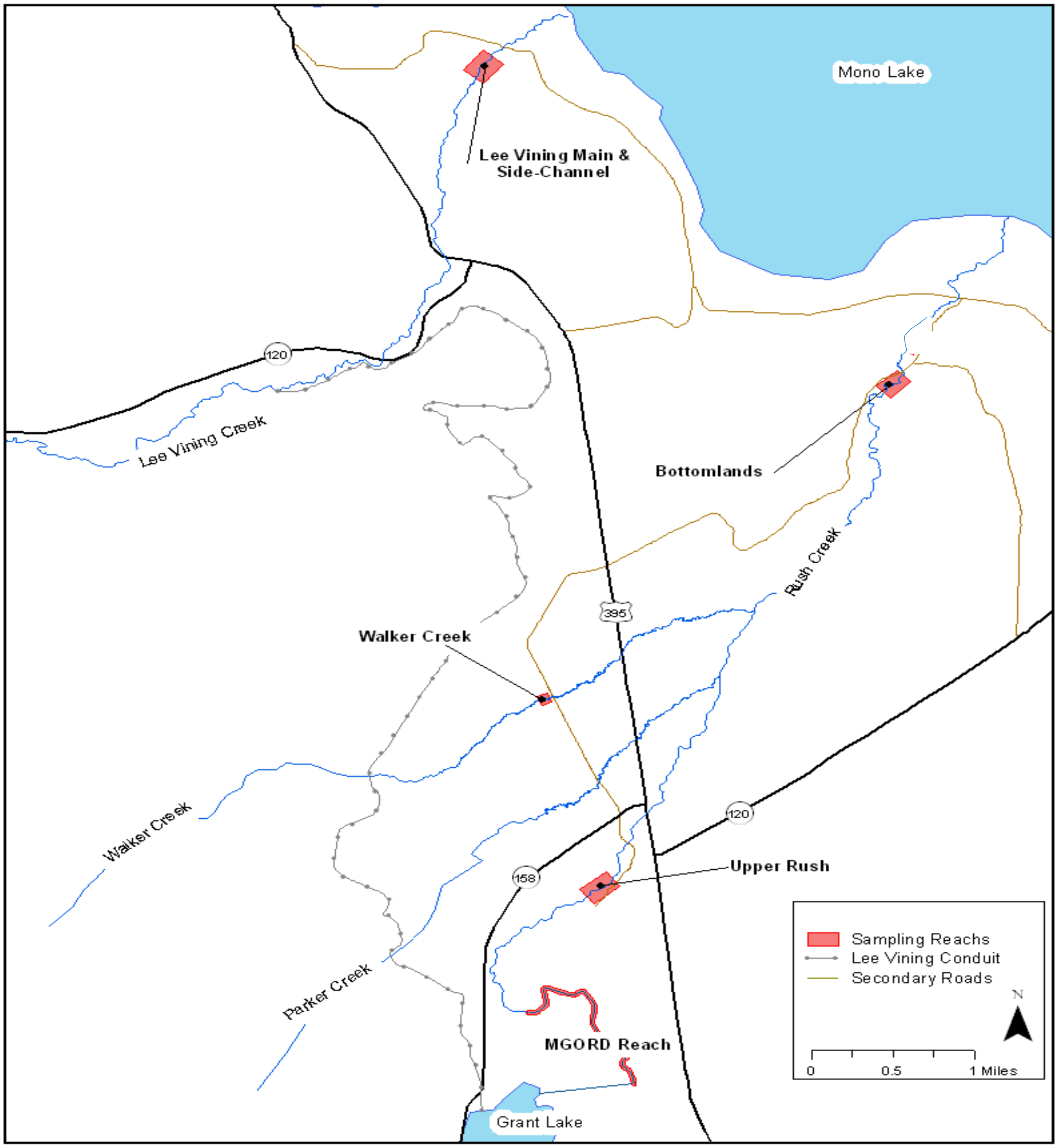

Figure 1. Annual fisheries sampling sites within Mono Basin study area, September 2015.

Hydrology

The 2015 runoff year (RY) was 25% of normal and classified a dry runoff year (RY) type, as measured on April 1st. However, more runoff occurred later in the spring due to record May-July precipitation. RY 2015 was the fourth consecutive dry runoff year type (RY 2014 was 48% of normal, RY 2013 was 66% of normal and RY 2012 was 55% of normal). Prescribed SRF summer baseflows for Rush and Lee Vining Creeks were 31 and 37 cfs, respectively.

Streamflow discharges in Rush Creek at Dam Site (located upstream of Grant Lake Reservoir) were irregular throughout 2015 due to SCE's operations (blue line on Figure 2). Flows released to Rush Creek downstream of Grant Lake Reservoir (GLR) were relatively constant throughout 2015, between 33 and 37 cfs, with a peak of approximately 48 cfs on March 3rd (red line on Figure 2). Accretions from Parker and Walker creeks resulted in minor flow fluctuations and a peak of 79 cfs in Rush Creek below the Narrows on June 1st (green line on Figure 2).

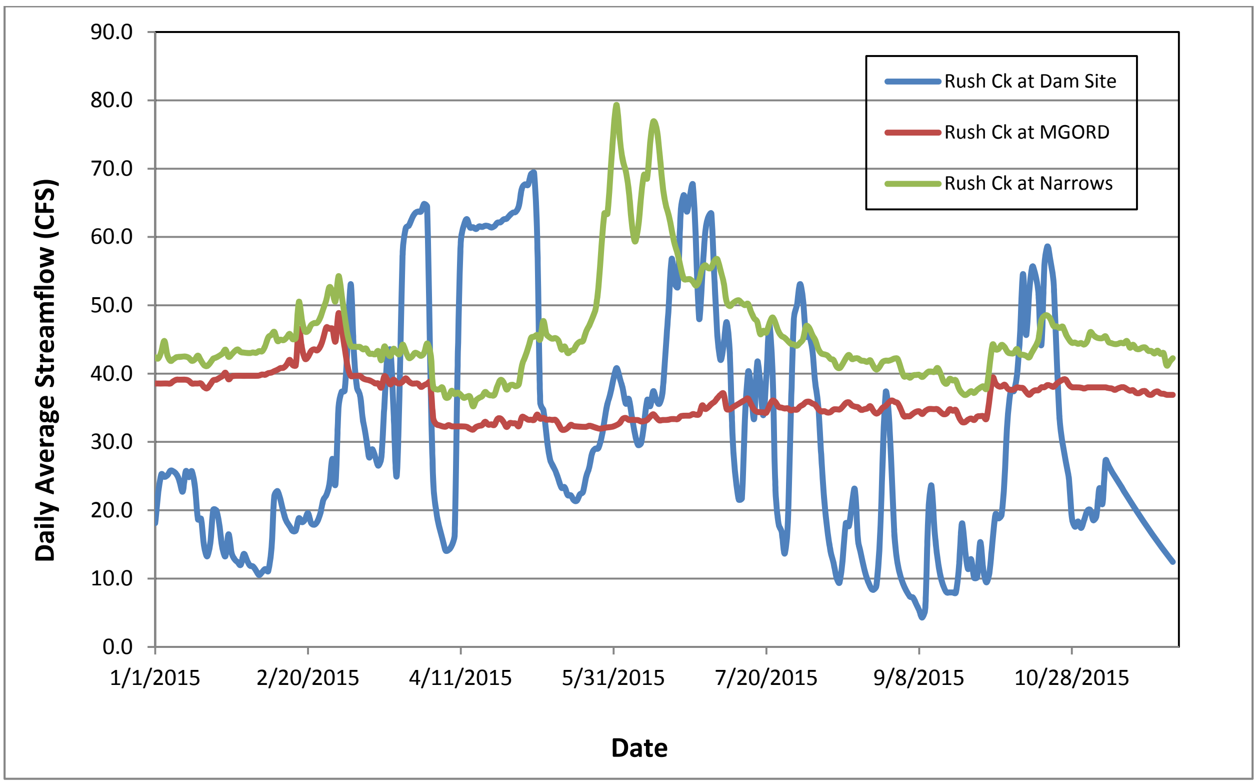

Figure 2. Rush Creek hydrographs between January 1st and November 30th of 2015.

Throughout 2015, flows in Lee Vining Creek below LADWP's intake never exceeded 40 cfs (Figure 3). Starting in late July, some minor flow irregularities occurred due to Southern Cal Edison releasing water upstream to drain reservoirs for dam repair and maintenance (Figure 3).

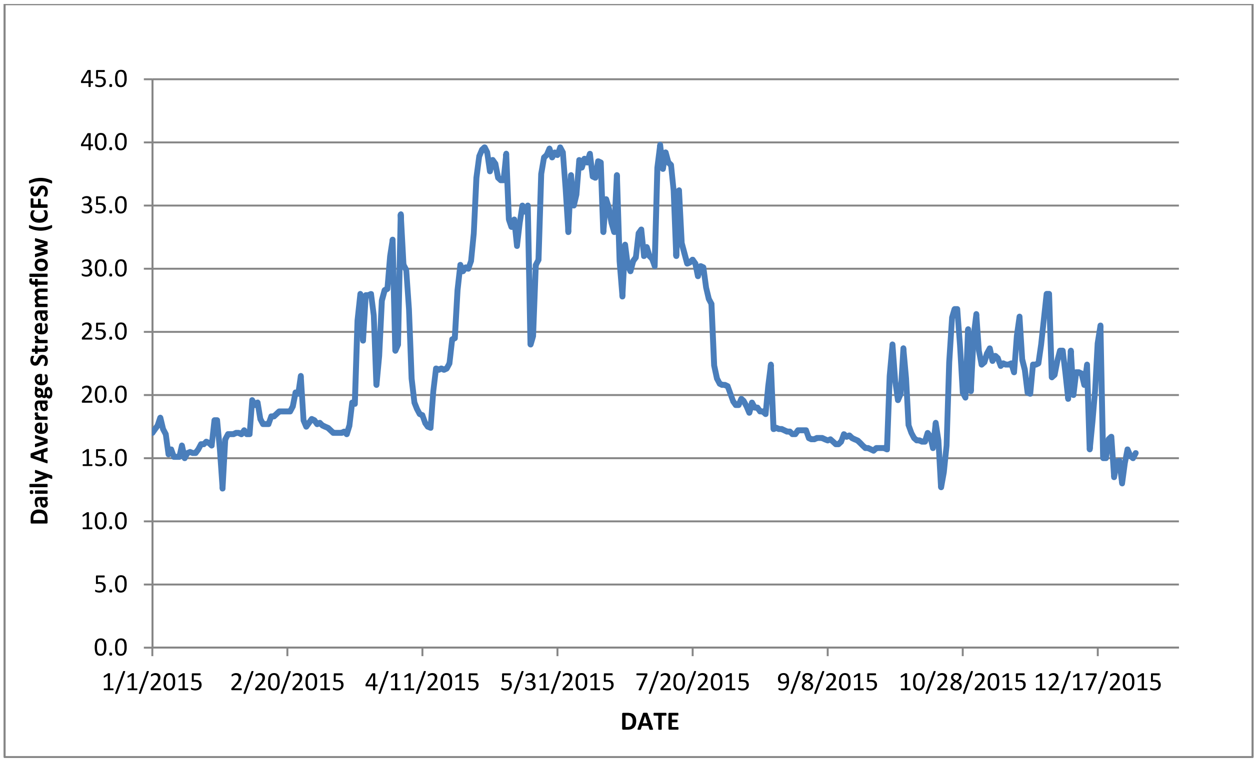

Figure 3. Lee Vining Creek hydrograph below LADWP intake between January 1st and December 31st of 2015.

Grant Lake Reservoir

In 2015, storage elevation levels in Grant Lake Reservoir (GLR) fluctuated from a low of 7,088.7 ft to a high of 7,098.4 ft (Figure 4). GLR's 2015 elevations were lower than 2014's elevations (which were lower than 2013's and 2012's); most likely due to the four consecutive dry RY's. For the three previous years, prior to snowmelt runoff GLR was at 7,118.8 ft on April 1, 2012, 7,114.2 ft on April 25, 2013, and at 7095.3 ft on April 1, 2014 (Figure 4). Between April 1st and 30th of 2015, GLR's storage elevation dropped 5.6 feet as LADWP exported their allotted 4,500 AF. Maximum GLR elevations have also decreased over the past four years. In 2012, GLR reached a maximum elevation of 7,127.6 ft on May 25th (2.4 ft below the spill elevation of 7,130 ft); in 2013 GLR's maximum elevation was 7,121.8 ft on July 3rd (8.2 ft below spill level and 5.8 ft lower than 2012's maximum level); in 2014 GLR's maximum elevation was 7,113.4 ft (16.6 feet below spill level and 8.4 feet lower than 2013's maximum level); and in 2015 GLR's maximum elevation was 7,098.4 ft (36.6 feet below spill level and 15.0 feet lower than 2014's maximum level) (Figure 4).

Between April 1st and September 30th, GLR's minimum elevation was 7,089.1 ft on April 30-May 1, 2015 (Figure 4). Throughout most of the summer of 2015, GLR's elevation was approximately six to nine feet below the "*low*" GLR level as defined in the Synthesis Report by the Stream Scientists as a level where warm water temperatures should be a concern (<20,000 AF storage or approximately 7,100 ft elevation) (Figure 4).

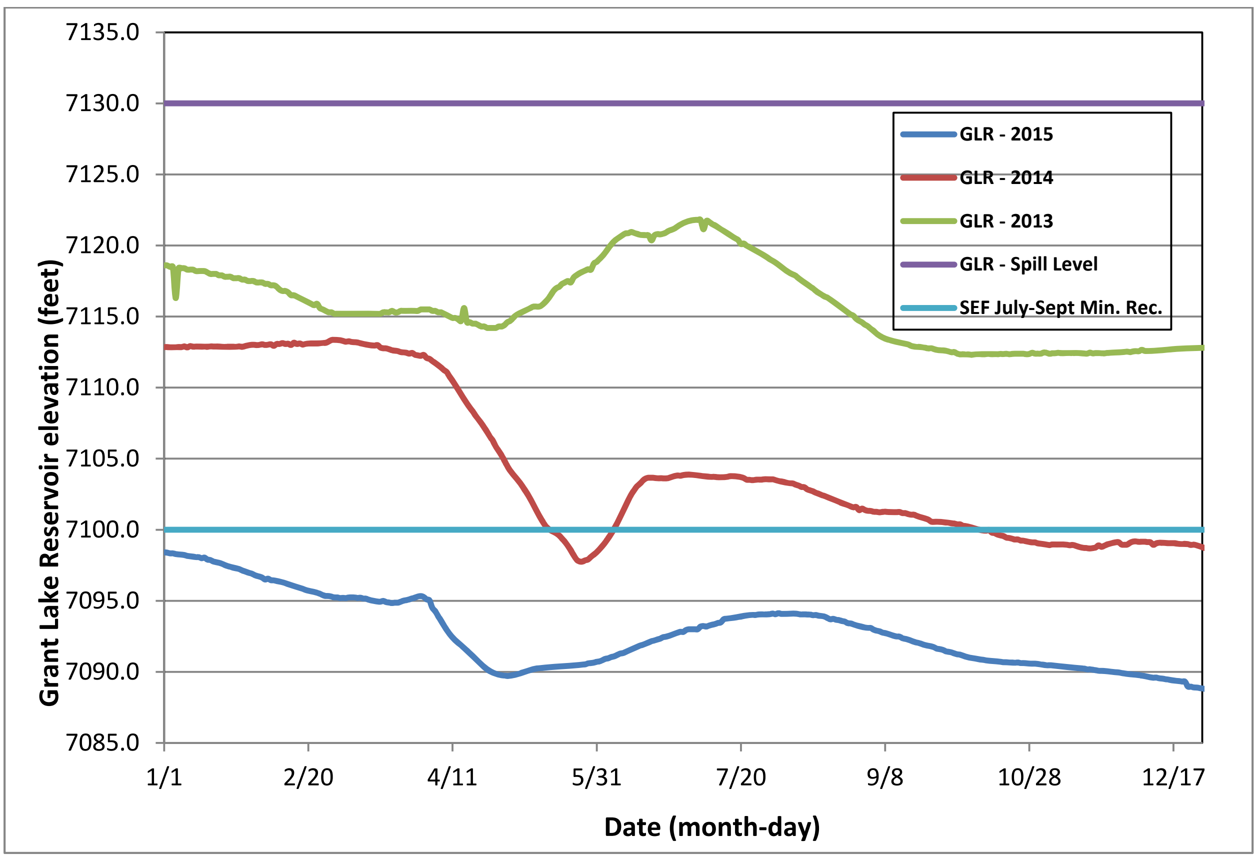

Figure 4. Grant Lake Reservoir's elevation between January 1st and December 31st 2015.

Methods

The annual fisheries monitoring was conducted between September 15th and 24th of 2015. Closed population mark-recapture and depletion methods were utilized to estimate trout abundance. The mark-recapture method was used on the Upper and Bottomlands sections of Rush Creek and the Lee Vining Creek main channel section. The depletion method was used on the Lee Vining Creek side channel and Walker Creek sections. A single electrofishing pass was made through the MGORD section of Rush Creek to assess condition factors, relative stock densities, and growth rates from PIT tag recaptures.

For the mark-recapture method to meet the assumption of a closed population, semi-permanent block fences were installed at the upper and lower ends of each section. The semi-permanent fences were 48 inches tall, constructed with ½ inch-mesh hardware cloth, t-posts, and rope. Hardware cloth was stretched across the entire width of the creek and t-posts were then driven at roughly five-foot intervals through the cloth on the upstream side approximately one foot from the edge. Rocks were placed on the lower edge to prevent trout from swimming underneath the fence. Rope was secured across the tops of the t-posts and tied to both banks upstream of the fence. The hardware cloth downstream of the t-posts was raised and secured to the rope with bailing wire. Fences were raised the morning of the mark run and left in place for seven days until the recapture run was finished. To prevent failure, all fences were cleaned of leaves, twigs, and checked for mortalities twice daily (morning and evening).

Depletion estimates only required temporary fencing to prevent fish movement in and out of the study area while conducting the survey. Temporary fencing was erected at the upper and lower ends of the study areas with 3/16 inch-mesh nylon seine nets installed across the channel. Rocks were placed on the lead line to prevent trout from swimming underneath the seine net. Sticks were used to keep the top of the seine above the water line. Both ends of the seine net were then tied to bank vegetation to hold it in place.

Equipment used to conduct mark-recapture electrofishing on Rush Creek included a six foot plastic barge that contained the Smith-Root© 2.5 GPP electro-fishing system, an insulated cooler, and battery powered aerators. The Smith-Root© 2.5 GPP electro-fishing system included a 5.5 horsepower Honda© generator which powered the 2.5 GPP control box. Electricity from the 2.5 GPP control box was introduced into the water via two anodes. The electrical circuit was completed by the metal plate cathode attached to the bottom of the barge. Due to the steep-gradient and relatively narrow width of Lee Vining Creek, two Smith-Root© LR-24 backpack electrofisher units were used for the mark-recapture runs.

Mark-recapture runs on Rush Creek consisted of a single downstream pass starting at the upper block fence and ending at the lower block fence. In 2015, the field crew consisted of a barge operator, two anode operators, and four netters, two for each anode. The barge operator's job consisted of carefully maneuvering the barge down the creek, and ensuring overall safety of the entire crew. The anode operator's job was to safely shock and hold trout until they were netted. The netters' job was to net and transport fish to the insulated cooler and monitor trout for signs of stress. Once the cooler was full, electrofishing was temporarily stopped to process the trout. The trout were then transferred from the cooler to live cars and placed back in the creek. The trout were then processed in small batches and then returned to a recovery live car in the creek. Once all the trout were processed at a sub-stop, the crew resumed electrofishing until the cooler was once again full.

Mark-recapture runs on Lee Vining Creek consisted of an upstream pass starting at the lower block fence and ending at the upper block fence, followed shortly by a downstream pass back to the lower block fence. The electrofishing crew consisted of two crew members running the backpack electrofishers, four netters, and one bucket carrier who transported the captured trout to several live cars positioned throughout the sample reach. Once the up-and-down passes were finished, the crew processed the trout.

Due to the depth of the MGORD, all electrofishing and netting was done from inside a drift boat. The drift boat was held perpendicular to the flow by two crew members who walked it down the channel. The electrofishing barge was tied off to the upstream side of the drift boat and a single throw anode was used. A single netter used a long handled dipnet to net the stunned trout, which were then placed in an insulated cooler equipped with aerators. A safety officer sat at the stern of the drift boat whose job was to monitor the trout in the cooler, the electrofishing equipment, the electrofishing crew and shut off the power should the need arise. Once the cooler was full, the trout were moved to a live car and placed back in the creek for the shore crew to process before continuing the electrofishing effort.

The Walker Creek and Lee Vining Creek side channel (B-1 side channel) depletions were both two-pass depletions. A single pass was considered an upstream pass from the lower seine net to the upper seine net followed by a downstream pass back to the lower seine net. One member of the electrofishing crew operated the LR-24 electrofisher; another member was the primary netter and a third member was the backup netter/bucket carrier. The other crew members processed the trout captured during the first pass while the electrofishing crew was conducting on the second pass. Processed first-pass fish were temporarily held in a live car until the second pass was completed and it was determined that only two passes were required to generate a suitable estimate. Once the electrofishing crew was finished with the second pass, those trout were then processed.

To process trout during the mark-run, small batches of fish from the live car were transferred to a five gallon bucket equipped with aerators. Trout were then anesthetized, identified as either brown trout or rainbow trout, measured to the nearest millimeter (total length), and weighed to the nearest gram on an electronic balance. Trout were then "marked" with a small (< 3 mm) fin clip for identification during the recapture run. Trout captured in the Rush Creek Bottom-lands section and the main channel of Lee Vining Creek received anal fin clips. Trout captured in the Upper section of Rush Creek received a lower caudal clip. Before placing trout into the aerated recovery bucket, each fish was examined for a missing adipose fin. Trout missing their adipose fin were then scanned for their Passive Integrated Transponder (PIT) tag number. Any trout missing their adipose fin that failed to produce a tag number when scanned were recorded as having "shed" the PIT tag; in most instances these fish were retagged. Partially regenerated adipose fins of fish with PIT tags were reclipped for ease of future identification. Once recovered, fish were then moved from the recovery bucket to a live car to be held until the day's sampling effort was completed; this was done to prevent captured fish from potentially moving downstream into the actively sampled section. At the end of the electrofishing effort, fish were released from the live cars back into the sub-sections they had been captured in. Fish were then provided a seven-day period to remix back into the section's population prior to conducting the recapture-run.

Processing trout during the recapture-run was similar to the mark-run. Trout were transferred in small batches to a five gallon bucket. They were then anesthetized, identified, and examined for the "mark" fin clip. Trout that were fin clipped were only measured to the nearest millimeter and placed in the recovery bucket. Trout that were not clipped during the "mark" run (i.e. new fish) were measured to the nearest millimeter "total length," weighed to the nearest gram, and examined for missing adipose fins. Trout missing adipose fins were then scanned for their PIT tag number then placed into recovery. Again, trout that failed to produce a tag number were recorded as having "shed" the PIT tag.

Between 2009 and 2012, PIT tags were implanted in most age-0 trout in Rush and Lee Vining Creeks and in all ages of trout in the MGORD. No PIT tags were deployed in 2013; however the tagging program was resumed during the 2104 field season.

All data collected in the field, were written on data sheets and entered into Excel spreadsheets using a field laptop computer. Data sheets were then used to proof the Excel spreadsheets.

Calculations

To calculate the area of each sample section, channel lengths and wetted widths were measured within the sample reaches. Wetted widths were measured at 10-meter intervals to 0.1 meter accuracy within each reach. Average wetted widths were used in area calculations which were then used to calculate each section's estimates of trout biomass and density.

Mark-recapture population estimates were derived from the Chapman modification of the Petersen equation (Ricker 1975 as cited in Taylor and Knudson 2011). Depletion estimates and condition factors were derived from MicroFish 3.0 software program. Estimates were generated for three size groups of trout: <125 mm in length, 125-199 mm in length, and ≥200 mm in length (200 mm is approximately eight inches).

Mortalities

For the purpose of conducting the mark-recapture methodology, accounting for fish killed during the sampling process was important. Depending on when the fish were killed and whether or not they were sampled during the mark-run, how these fish were accounted for varied.

All fish killed during the mark-run were unavailable for sampling during the recapture-run. These fish were considered "morts" in the mark-run for the purposes of mark-recapture estimates, were removed from the mark-run data, and then were added back into the total estimate after computing the mark-recapture estimate.

During the seven-day period between the mark-run and the recapture-run, when the block fences were cleaned twice daily, fence cleaners also looked for additional morts. When "marked" morts were found on the fences, we went back into the mark-run data and assigned block fence morts on a one-to-one basis as "morts" to individual fish on the mark-run based on species and size. When this occurred, a comment was added to the individual fish, such as "assigned as fence mort". These marked morts were then removed from the mark-run data since they were unavailable for sampling during the recapture-run. Because of fin deterioration on some morts, exact lengths were not always available. Fortunately, it was not critical to match the exact length when assigning these marked fence morts to fish from the mark-run, but it was important that the fence morts were placed within the proper "length group" for which estimates were computed. As with fish killed during the mark-run, these marked fence morts were added back into the total estimate after the mark-recapture estimate was computed.

Unmarked fence morts (fish not caught and clipped during the mark-run) were measured and tallied by the three length groups for which estimates were computed. These fish were then added to the total number of morts (for each length group), which were then added back into the mark-recapture estimates to provide unbiased total estimates for each length group.

Length-Weight Relationships

Length-weight regressions (Cone 1989 as cited in Taylor and Knudson. 2011) were calculated for all brown trout greater than 100 mm in all sections of Rush Creek. Regressions using Log10 transformed data were used to compare length-weight relationships by year and by section.

Fulton-type condition factors were computed in MicroFish 3.0 using methods previously reported (Taylor and Knudson 2011) for brown trout 150 to 250 mm. A trout condition factor of 1.00 was considered average (Reimers 1963; Blackwell et al. 2000).

Relative Stock Density (RSD) Calculations

Relative stock density (RSD) is a numerical descriptor of length frequency data (Hunter et al. 2007). RSD values are the proportions (percentage x 100) of the total number of brown trout ≥150 mm in length that are also ≥225 mm or (RSD-225), ≥300 mm (RSD-300) and ≥375 mm or (RSD-375). These three RSD values are calculated by the following equations:

RSD-225 = [(# of brown trout ≥225 mm) ÷ (# of brown trout ≥150 mm)] x 100
RSD-300 = [(# of brown trout ≥300 mm) ÷ (# of brown trout ≥150 mm)] x 100
RSD-375 = [(# of brown trout ≥375 mm) ÷ (# of brown trout ≥150 mm)] x 100

Termination Criteria Calculations and Analyses

Information regarding the proposed termination criteria, calculations, and analyses was conducted as described in past Annual Fisheries Reports (Taylor and Knudson 2011).

Water Temperature Monitoring

Water temperatures were recorded (in Fahrenheit) at nine locations within Rush and Lee Vining creeks as part of the fisheries monitoring program. Data loggers were deployed in January and collected data throughout the year in one-hour time intervals. Data loggers were downloaded at the end of the year and the data were summarized in spreadsheets. Water temperature data loggers were deployed at the following locations in 2015:

1. Rush Creek at Damsite – upstream of GLR.
2. Rush Creek – top of MGORD.
3. Rush Creek – bottom of MGORD.
4. Rush Creek – at old Highway 395 Bridge.
5. Rush Creek – below Narrows.
6. Rush Creek – at 10-channel.
7. Rush Creek – at County Road crossing.
8. Lee Vining Creek – below LADWP intake.
9. Lee Vining Creek – at County Road crossing.

For the fisheries monitoring program, the year-long data sets were edited to focus on summer water temperature regimes (July – September) in Rush and Lee Vining creeks, with particular focus on Rush Creek. Analysis of summer water temperature included the following metrics:

1. Daily mean temperature.
2. Average daily minimum temperature.
3. Average daily maximum temperature.
4. Number of days with daily maximums exceeding 70^{o}F.
5. Number of hours with temperatures exceeding 66.2^{o}F.
6. Number of good/fair/poor potential growth days, based on daily average temperature.
7. Number of bad thermal days based on daily average temperature.
8. Maximum diurnal fluctuations.
9. Average maximum diurnal fluctuation for consecutive 21-day period.

Results

Channel Lengths and Widths

Differences in wetted widths between years can be due to several factors such as, magnitude of spring peak flows, stream flows at time of measurements, and locations of where the measurements were taken. In 2015, widths in the Rush Creek Bottomlands, Walker Creek, and Lee Vining sections were slightly narrower than in 2014; whereas in the Upper section of Rush Creek the 2015 width was slightly wider than the 2014 measurement. Lengths, widths, and areas from 2014 are provided for comparisons (Table 1).

Table 1. Total length, average wetted width, and total surface area of sample sections in Rush, Lee Vining, and Walker Creeks sampled between September 15-24, 2015. Values from 2014 are provided for comparisons.

Sample Section	Length (m) 2014	Width (m) 2014	Area (m^2) 2014	Length (m) 2015	Width (m) 2015	Area (m^2) 2015	Area (ha) 2015
Rush – Upper	430	7.2	3,096.0	430	7.3	3,139.0	0.3139
Rush - Bottomlands	437	7.0	3,059.0	437	6.7	2,927.9	0.29279
Rush – MGORD	2,230	8.3	18,509.0	2,230	8.3	18,509.0	1.8509
Lee Vining – Main	255	5.5	1,402.5	255	4.8	1,224.0	0.1224
Lee Vining - Side	127	1.5	190.5	70.3	1.0	70.3	0.00703
Walker Creek	193	1.9	366.7	193	1.7	328.1	0.03281

Trout Population Abundance

Rush Creek

In 2015, a total of 759 brown trout ranging in size from 75 mm to 480 mm were captured in Upper Rush section (Figure 5). For comparison, in 2014, a total of 1,056 brown trout ranging in size from 59 mm to 370 mm were captured in the Upper Rush section. In 2015, age-0 brown trout comprised 57% of the total catch this year (compared to 62% in 2014). The Upper Rush section supported an estimated 647 age-0 brown trout in 2015 (including morts) compared to 1,309 age-0 brown trout in 2014 and 2,046 age brown trout in 2013 (a 51% decrease between 2014 and 2015 and a 68% decrease between 2013 and 2015). Between 2012 and 2015 (the four consecutive dry years), the estimate of age-0 brown trout in Upper Rush has decreased from 2,895 to 647 fish (a 78% decrease). Standard error for the 2015 age-0 brown trout estimate was 5% of the estimate, a slight decrease from the 7% value in 2014 (Table 2).

In 2015, brown trout 125-199 mm in length comprised 30% of the total catch in the Upper Rush section (compared to 31% in 2014). This section supported an estimated 297 brown trout 125-199 mm in length in 2015 (including morts) compared to 553 fish in 2014 (a 46% decrease). Between 2012 and 2015 (the four consecutive dry years), the estimate of brown trout 125-199 mm in Upper Rush has decreased from 492 to 297 fish (a 40% decrease). Standard error for this size class was 5% of the estimate (was 8% for the 2014 estimate).

Brown trout ≥200 mm in length comprised of 13% of the Upper Rush total catch in 2015 (compared to 7% in 2014 and 8% in 2013). In 2015, Upper Rush supported an estimated 117 brown trout ≥200 mm in length compared to an estimate of 105 fish in 2014 (a 11% increase). Between 2012 and 2015 (the four consecutive dry years), the estimate of brown trout ≥200 mm in Upper Rush has decreased from 177 to 117 fish (a 34% decrease). Standard error for this size class was 5% of the 2015 estimate versus 11% in 2014. In 2015, two brown trout ≥300 mm in length were captured in the Upper Rush section; these fish were 400 and 480 mm in length (Figure 5).

A total of 14 rainbow trout were captured on the Upper Rush section comprising 1.8% of the section's total catch in 2015. The 14 rainbow trout ranged in size from 75 mm to 202 mm (Figure 6). Twelve of the captured rainbow trout were age-0 fish, one fish was in the 125-199 mm size class, and one fish was ≥200 mm in length. In 2015, there were too few recaptures of rainbow trout to generate estimates for any of the size classes.

Within the Bottomlands section of Rush Creek a total of 393 brown trout were captured in 2015 (Table 2) which ranged in size from 68 mm to 470 mm (Figure 7). For comparison, 330 brown trout were captured in 2014 which ranged in size from 65 mm to 440 mm. Age-0 brown trout comprised 67% of the total catch in 2015 versus 31% of the total catch in 2014 and 50% in 2013. The Bottomlands section supported an estimated 465 age-0 brown trout in 2015 versus 174 age-0 fish in 2014 (a 167% increase). Between 2012 and 2015 (the four consecutive dry years), the estimate of age-0 brown trout in the Bottomlands section has decreased from 843 fish to 465 fish (a 45% decrease). Standard error on age-0 brown trout was 9% of the estimate in 2015 compared to 14% in 2014 (Table 2).

Brown trout 125-199 mm in length comprised 19% of the total catch in the Bottomlands section in 2015 versus 61% of the total catch in 2014. This section supported an estimated 96 brown trout 125-199 mm in length in 2015 compared to 276 fish in 2014 (a 65% decrease). Between 2012 and 2015 (the four consecutive dry years), the estimate of 125-199 mm brown trout in the Bottomlands section decreased from 460 to 96 fish (a 79% decrease). Standard error for this size class was 7% of the estimate in 2015 versus 7% in 2014 (Table 2).

Brown trout ≥200 mm in length comprised of 14% of the total catch in 2015 (8% in 2014) with the largest trout 470 mm in length. The Bottomlands section supported an estimated 62 brown trout ≥200 mm in 2015 compared to 30 trout in 2014 (a 107% increase). Although the estimate of brown trout ≥200 mm has increased over the past three years, between 2012 and 2015 (the four consecutive dry years), the estimate has decreased by 37%. Standard error for this size class was 6% of the 2015 estimate versus 10% in 2014 (Table 2). In 2015, one brown trout ≥300 mm was captured in the Upper Rush section; this fish was 470 mm in length (Figure 7).

In 2015, two rainbow trout were captured in the Bottomlands section of Rush Creek (Figure 8). These two rainbow trout were 184 and 187 mm in length and comprised 0.5% of the 2015 total catch in the Bottomlands section. No estimates of rainbow trout were possible due to insufficient numbers.

Table 2. Rush Creek and Lee Vining Creek mark-recapture estimates for 2015 showing total number of trout marked (M), total number captured on the recapture run (C), total number recaptured on the recapture run (R), and total estimated number and its associated standard error (S.E.) by stream, section, date, species, and size class. Mortalities (Morts) were those trout that were captured during the mark run, but died prior to the recapture run. Mortalities were not included in mark-recapture estimates and were added to estimates for accurate total estimates. NP = estimate not possible. BNT = brown trout RBT = rainbow trout

Stream Section Species Date	Size Class (mm)	Mark - recapture estimate M	C	R	Morts	**Estimate**	S.E.
Rush Creek							
Upper Rush-BNT							
9/15/2015 & 9/22/2015							
	0 - 124 mm	295	241	110	3	**644**	35
	125 - 199 mm	156	149	78	0	**297**	16
	>200 mm	80	72	49	0	**117**	6
Bottomlands-BNT							
9/16/2015 & 9/23/2015							
	0 - 124 mm	147	165	52	2	**465**	42
	125 - 199 mm	49	55	28	0	**96**	8
	>200 mm	41	41	27	0	**62**	4
Lee Vining Creek							
Main Channel-BNT							
9/17/2015 & 9/24/2015							
	0 - 124 mm	144	122	70	1	**250**	14
	125 - 199 mm	108	108	62	2	**190**	10
	>200 mm	44	35	28	0	**55**	3
Main Channel-RBT							
9/17/2015 & 9/24/2015							
	0 - 124 mm	0	0	0	0	**0**	0
	125 - 199 mm	9	8	6	0	**12**	1
	>200 mm	9	6	6	0	**9**	0

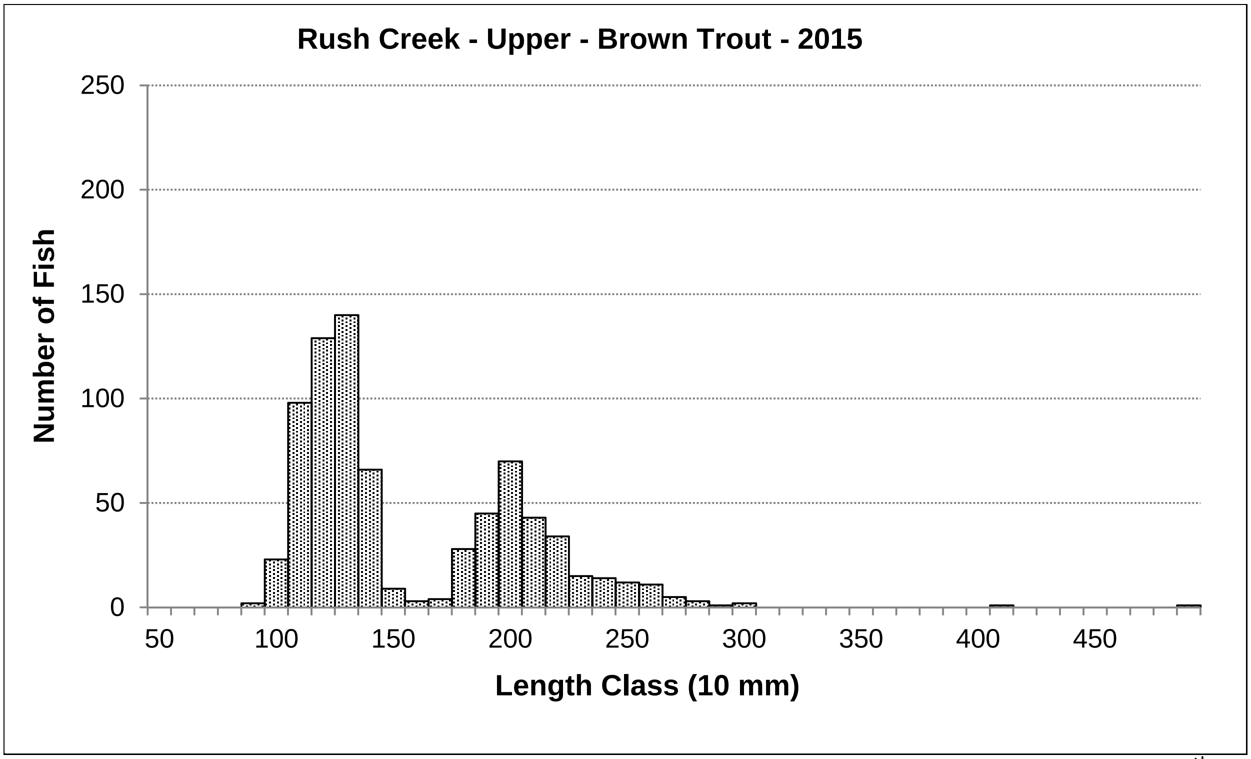

Figure 5. Length-frequency histogram for Upper Rush captured brown trout, September 15th and 22nd, 2015.

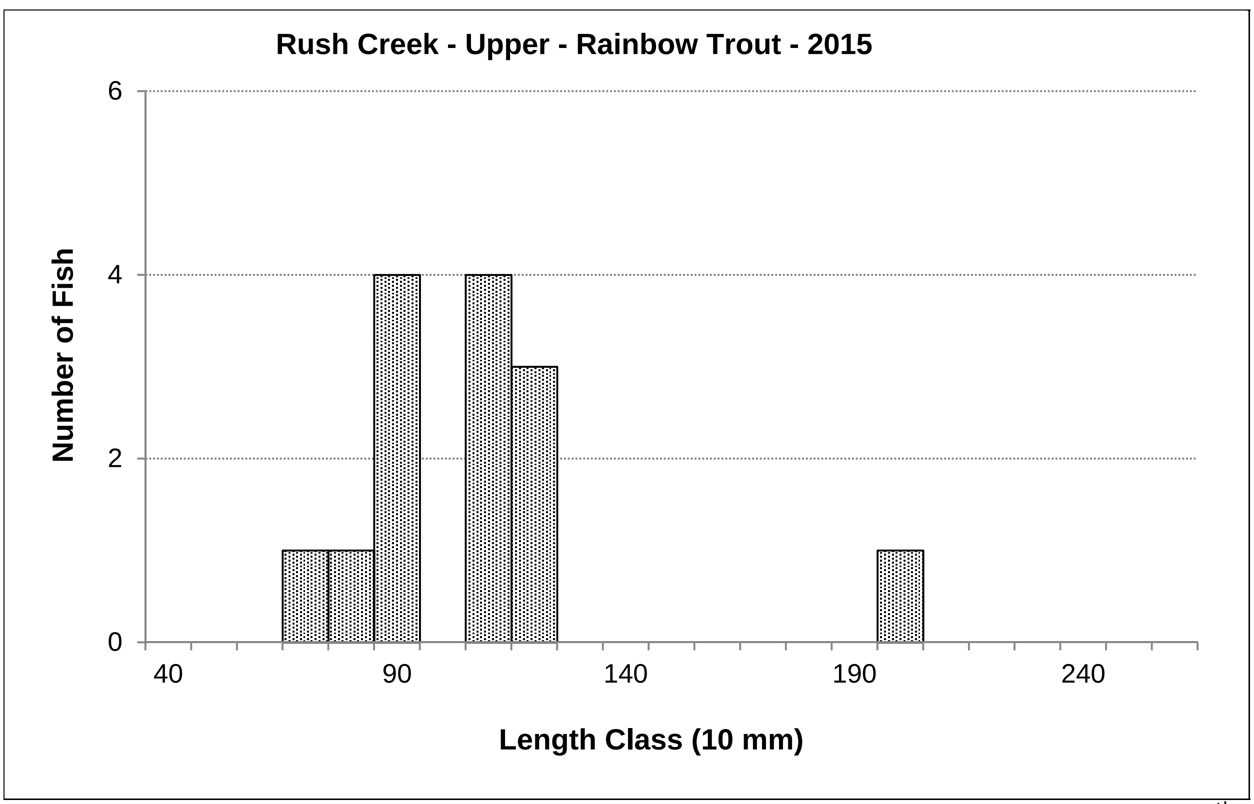

Figure 6. Length-frequency histogram for Upper Rush captured rainbow trout, September 15th and 22nd, 2015.

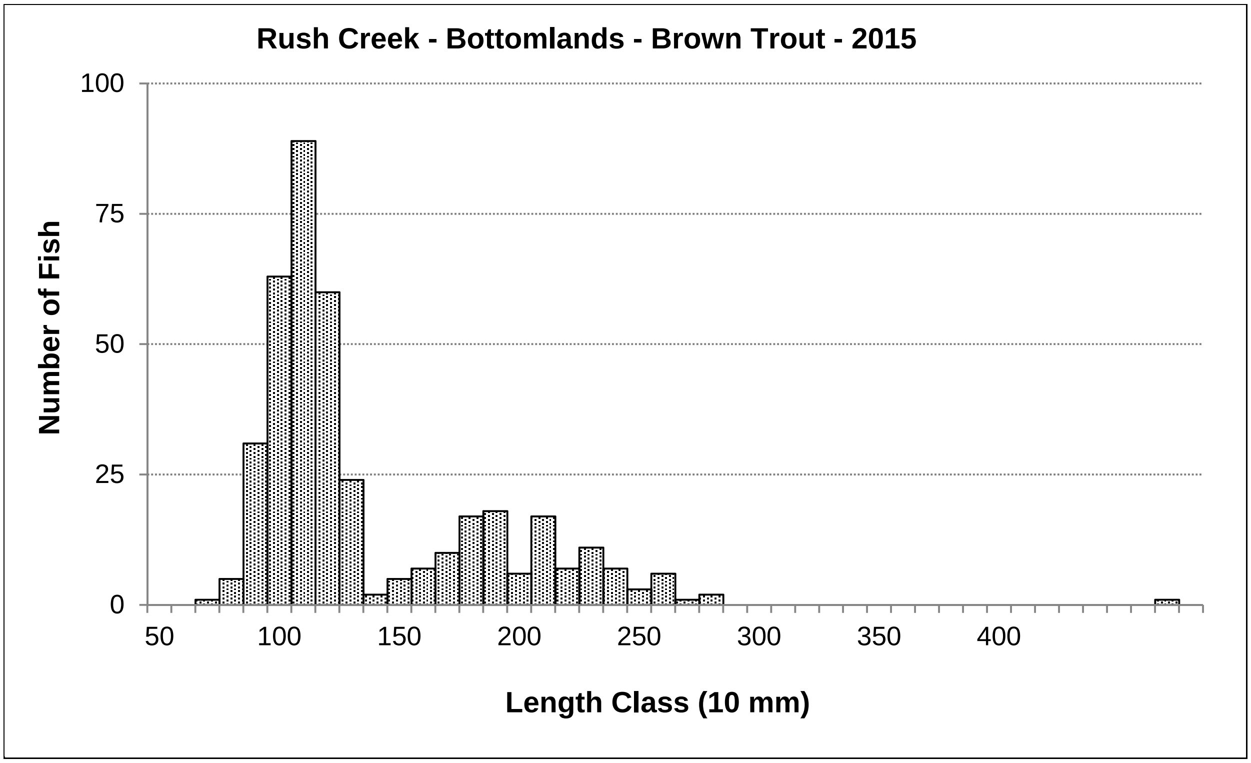

Figure 7. Length-frequency histogram of captured brown trout in the Bottomlands section of Rush Creek, September 16th and 23rd, 2015.

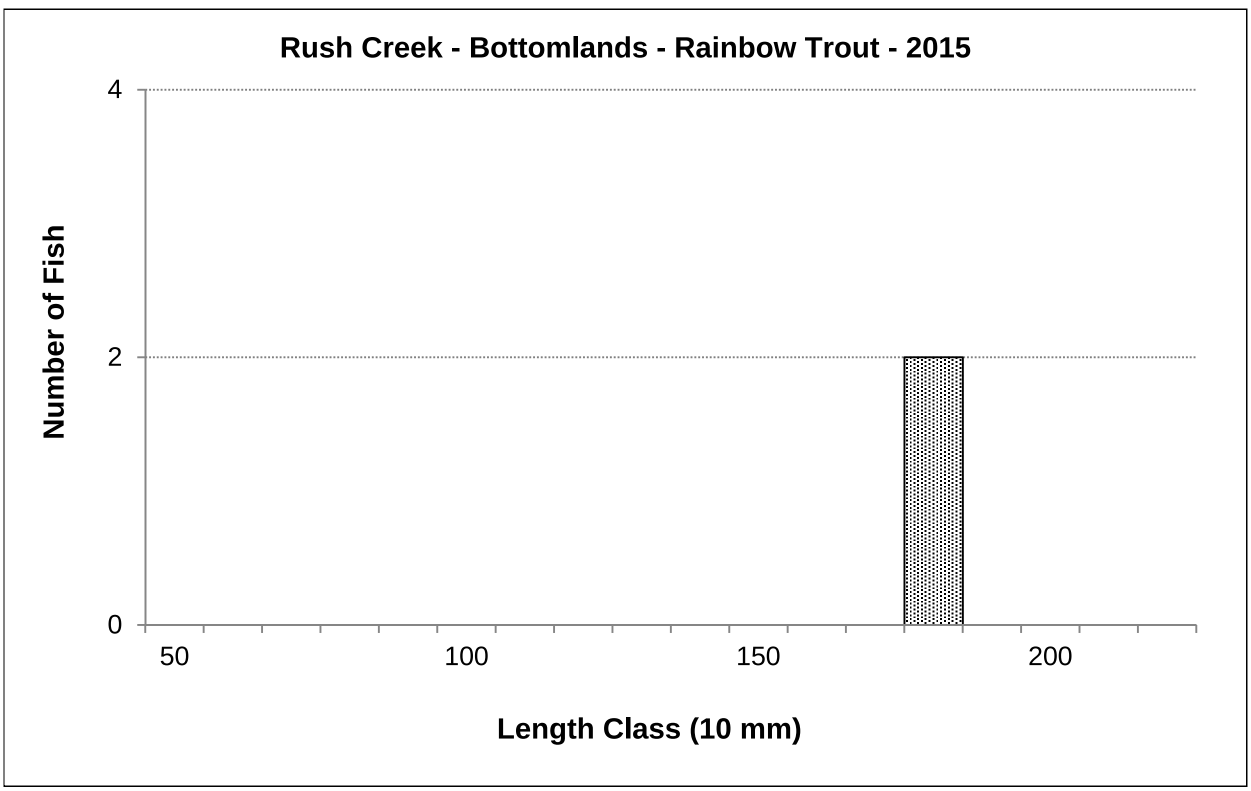

Figure 8. Length-frequency histogram of captured rainbow trout in the Bottomlands section of Rush Creek, September 16th and 23rd, 2015.

Within the MGORD section of Rush Creek a total of 174 brown trout were captured during the single electrofishing pass made in 2015 and these fish ranged from 92 mm to 495 mm in length (Figure 9). Age-0 brown trout comprised 17% of the total number of brown trout captured in 2015, compared to 5% of the brown trout captured in 2014.

In 2015, the 40 brown trout in 125-199 mm size class comprised 23% of the total catch in the MGORD section. For comparison, in 2014 brown trout in 125-199 mm size class also comprised 23% of the total catch in the MGORD section.

Brown trout ≥200 mm in length comprised of 60% of the total catch in 2015, compared to 72% of the total catch in 2014. In 2015, 29 brown trout ≥300 mm were captured in the MGORD (17% of the total catch). Nine brown trout ≥375 mm in length were captured in 2015 and six of these fish were >400 mm in length.

In 2015, two rainbow trout were captured on the MGORD. In the previous three years, no rainbow trout were captured in 2014, nine rainbow trout were captured in 2013 and 40 rainbow trout were captured in 2012.

The 176 trout (browns and rainbows combined) captured in 2015 was the lowest total catch for a single electrofishing pass through the MGORD section of Rush Creek. For the previous nine sampling years, single electrofishing passes through the MGORD have produced the following total catch values:

- 2014 – Mark run = 206 trout. Recapture run = 268 trout. Two-pass average = 237 fish.
- 2013 – Single pass = 451 trout.
- 2012 – Mark run = 606 trout. Recapture run = 543 trout. Two-pass average = 574.5 fish.
- 2011 – Single pass = 244 trout.
- 2010 – Mark run = 458 trout. Recapture run = 440 trout. Two-pass average = 449 fish.
- 2009 – Single pass = 649 trout.
- 2008 – Mark run = 450 trout. Recapture run = 419 trout. Two-pass average = 434.5 fish.
- 2007 – Single pass = 685 trout.
- 2006 – Mark Run = 283 trout. Recapture run = 375 trout. Two-pass average = 329 fish.

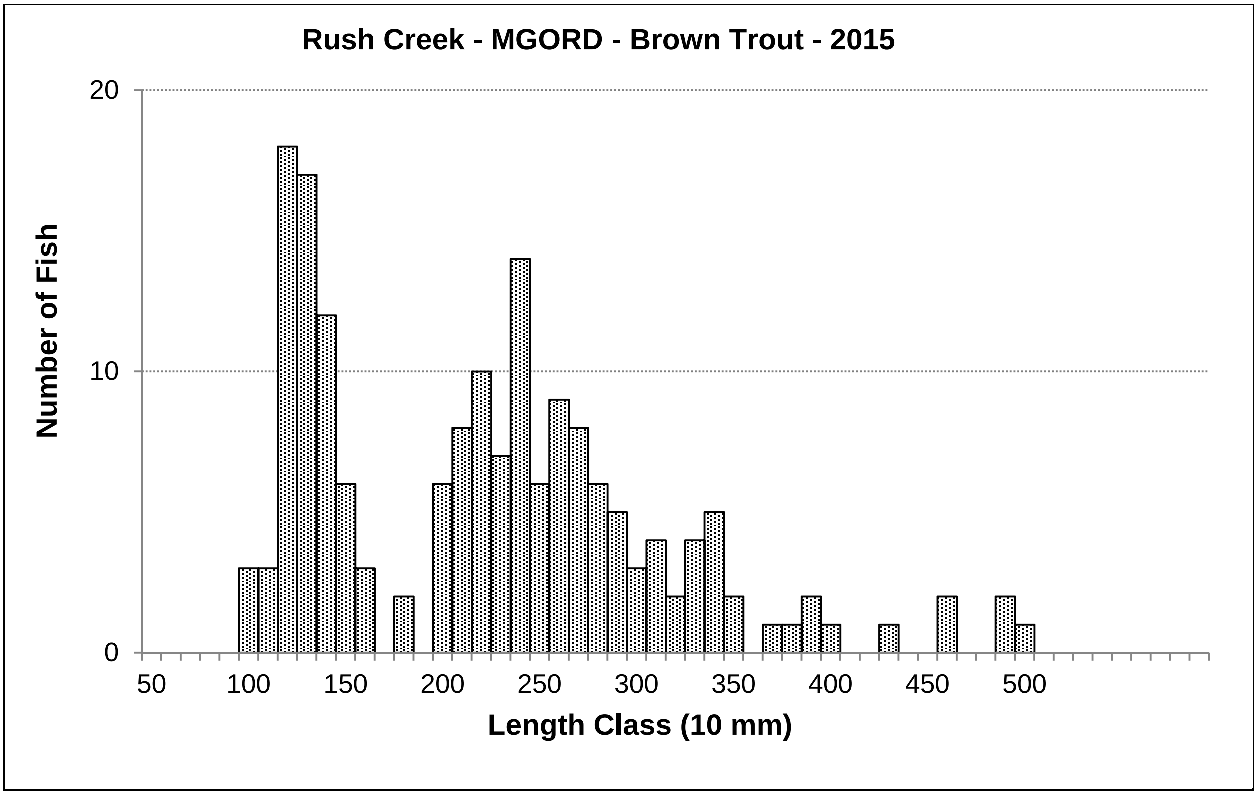

Figure 9. Length-frequency histogram of captured brown trout in the MGORD section of Rush Creek, September 18th 2015.

Lee Vining Creek

In 2015, a total of 422 trout were captured in the Lee Vining Creek main channel section (versus 414 fish in 2014, 658 fish in 2013 and 838 fish in 2012) (Table 2). Of the 422 trout captured in 2015, 402 were brown trout making up 95% of the total trout captured. In 2015, brown trout ranged in size from 76 mm to 255 mm (Figure 10). Age-0 fish comprised 49% of the total brown trout catch in 2015 (compared to 37% in 2014 and 45% in 2013). Lee Vining Creek's main channel section supported an estimated 251 age-0 brown trout in 2015, compared to an estimated 242 age-0 brown trout in 2014 (a 4% increase). Between 2012 and 2015 (the four consecutive dry years), the age-0 brown trout estimates dropped from 677 fish to 251 fish (a 63% decrease). Standard error for age-0 brown trout was 6% of the 2015 estimate vs. 2014's 13% (Table 2).

In 2015, 154 brown trout 125-199 mm in length were captured and comprised 38% of the total brown trout catch in Lee Vining Creek's main channel section (versus 55% in 2014). This section supported an estimated 192 brown trout 125-199 mm in length in 2015 (Table 2) compared to 276 fish in 2014 (a 30% decrease). Standard error for this size class in 2015 was 5% of the estimate compared to 7% in 2014.

Brown trout ≥200 mm in length comprised of 13% of the total brown trout catch in 2015 (versus 8% in 2014). Lee Vining Creek's main channel supported an estimated 55 brown ≥200 mm (versus 34 fish in 2014) (Table 2). Standard error for this size class was 5% of the 2015 estimate vs. 26% in 2014.

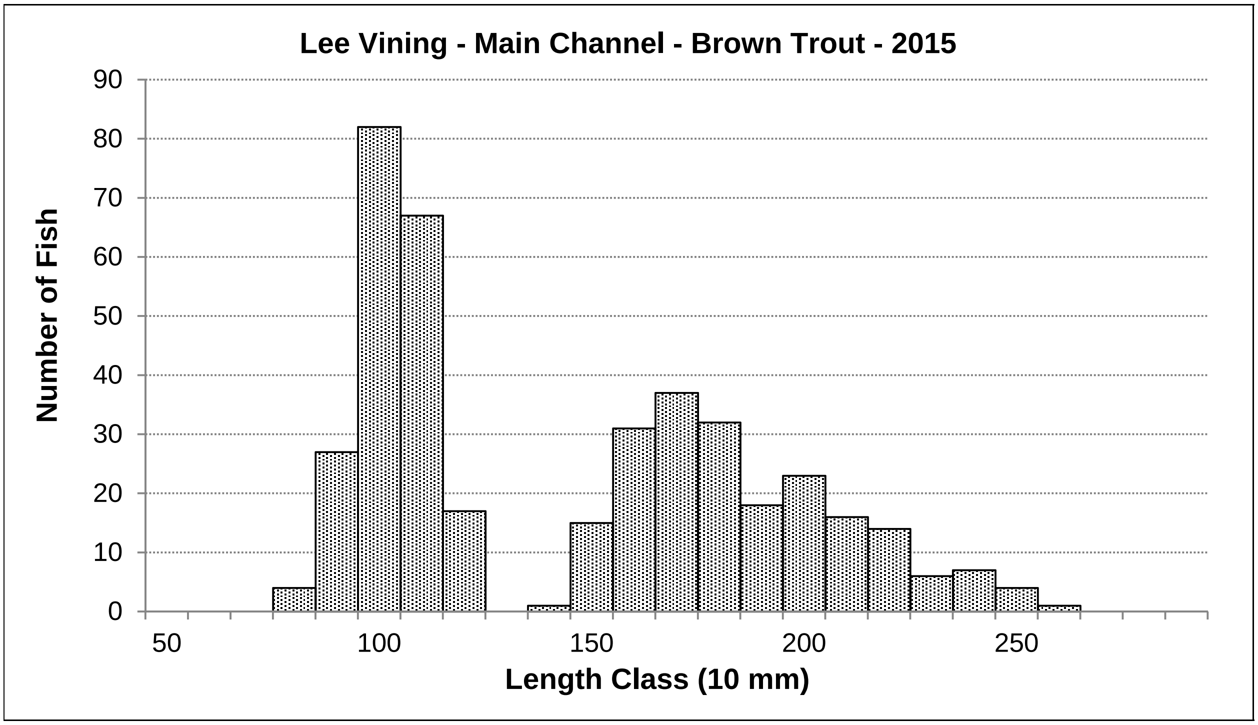

Figure 10. Length-frequency histogram of captured brown trout in the main channel section of Lee Vining Creek, September 17th and 24th, 2015.

A total of 20 rainbow trout were captured in Lee Vining's main channel making up approximately 5% of the total catch in 2015 (versus 14% of the 2014 total catch and 19% of the 2013 total catch) (Table 2). Rainbow trout ranged in size from 130 mm to 284 mm; none were in the <125 mm (or age-0) size class (Figure 11).

The 11 rainbow trout captured in the 125-199 mm size class comprised 55% of the total rainbow trout catch in 2015. The 2015 estimate for rainbow trout in this size class was 12 fish (Table 2) versus estimates of 47 fish in 2014 (a 74% decrease) and of 94 fish in 2013 (an 87% decrease). In 2015, the standard error was 8% of the estimate compared to a standard error 13% of the estimate in 2014 (Table 2).

The nine rainbow trout caught in Lee Vining Creek's main channel ≥200 mm in length comprised 54% of the total rainbow trout catch in 2015. The 2015 estimate for rainbow trout in this size class was nine fish (Table 2) versus estimates of 16 fish in 2014 (a 44% decrease) and of 26 fish in 2013 (a 65% decrease). In 2015, the standard error was zero compared to a standard error that was 6% of the estimate in 2014 (Table 2).

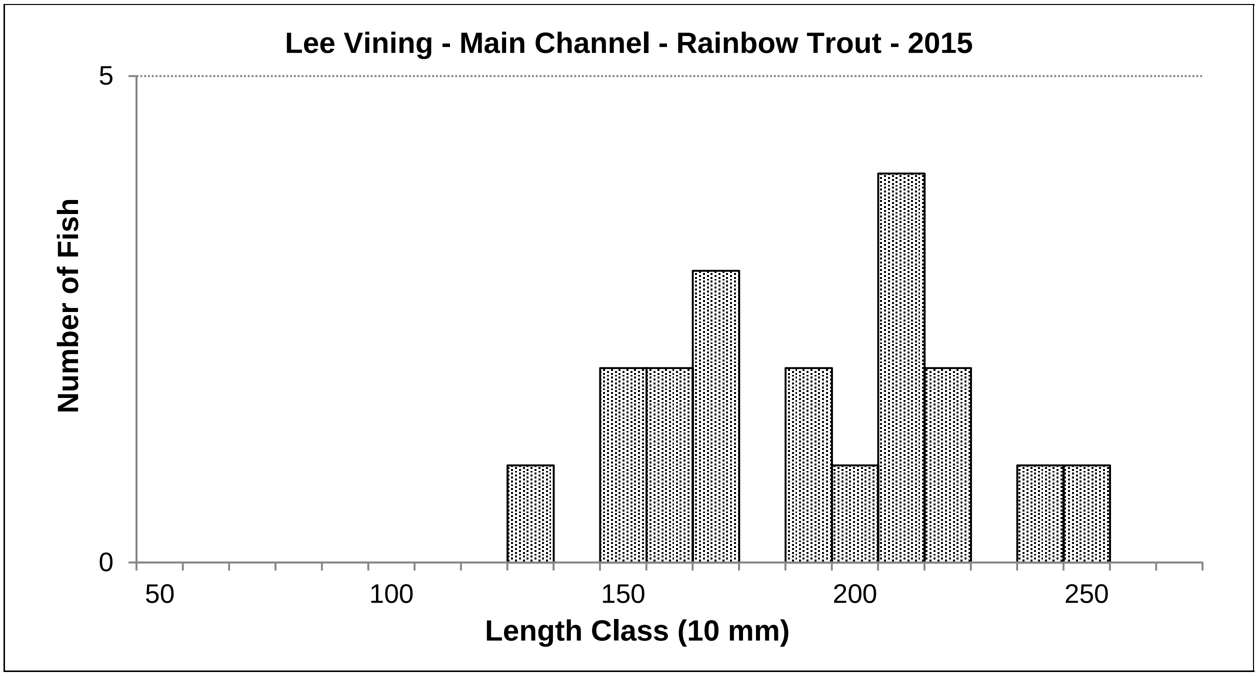

Figure 11. Length-frequency histogram of captured rainbow trout in the main channel section of Lee Vining Creek, September 17th and 24th, 2015.

In the Lee Vining Creek side channel, seven brown trout were captured in two electrofishing passes during the 2015 sampling (Table 3). No age-0 fish were captured and all seven fish were 125-199 mm in length and caught on the first pass (Figure 12). The estimate for this size class was seven brown trout (Table 3). No rainbow trout were captured in the side channel in 2015. This was the seventh consecutive year that no age-0 rainbow trout were captured in the Lee Vining Creek side channel and the fifth consecutive year the no age-1+ rainbows were captured.

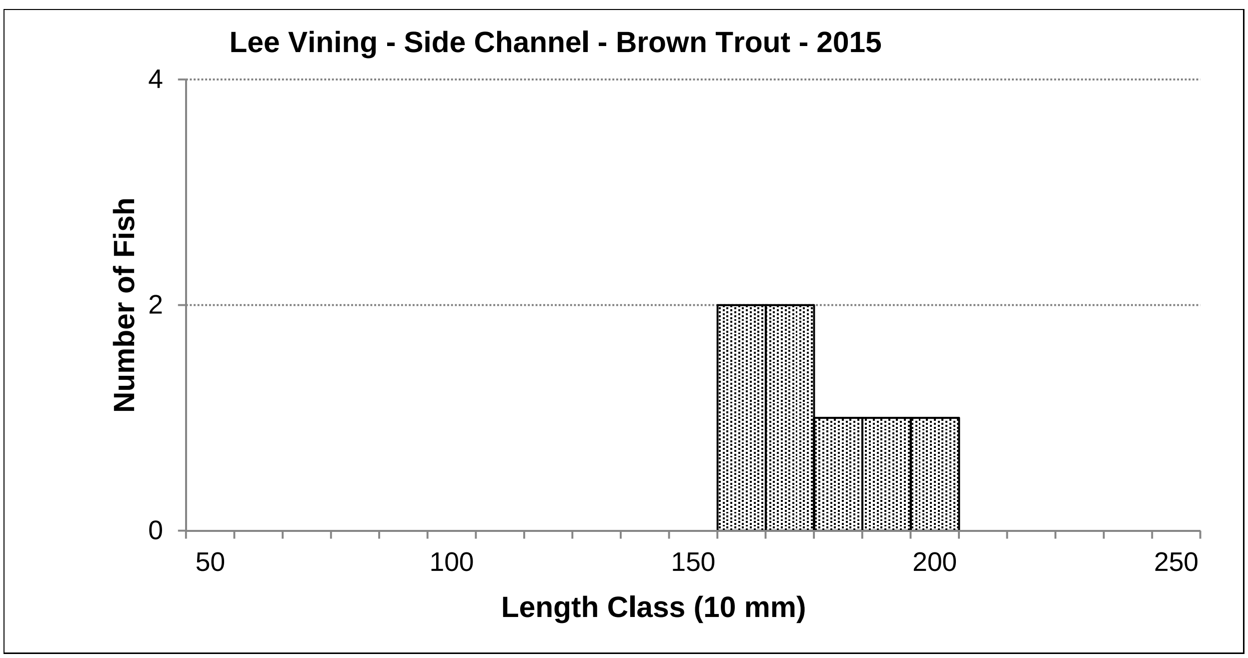

Figure 12. Length-frequency histogram of captured brown trout in the side channel section of Lee Vining Creek, September 19th, 2015.

Walker Creek

In 2015, a total of 190 brown trout were captured in two electrofishing passes in the Walker Creek section (185 brown trout were captured in 2014 and 345 brown trout were captured in 2013) (Table 3). Of these, 112 brown trout or 59% were age-0 fish ranging in size from 75 mm to 117 mm in length (Figure 13). The 2015 age-0 brown trout estimate for Walker Creek was 112, a 100% increase from the 2014 estimate of 56 fish. The 2015 estimate was still a 53% decrease from the 2013 estimate of 236 age-0 brown trout. For trout <125 mm in length, the 2015 probability of capture was 93% (Table 3).

Brown trout in the 125-199 mm size class (59 fish) accounted for 31% of the total catch in 2015 (compared to 62% in 2014 and 28% in 2013). The 2015 population estimate for brown trout in the 125-199 mm size class was 59 trout with a probability of capture of 94%(Table 3).

Brown trout ≥200 mm in length (19 fish) accounted for 10% of the total catch in 2015 (was 11% in 2014 and 6% in 2013). The 2015 population estimate for this size class was 19 brown trout with a probability of capture of 95% (Table 3). The largest brown trout captured in Walker Creek in 2015 was 249 mm in length (Figure 13).

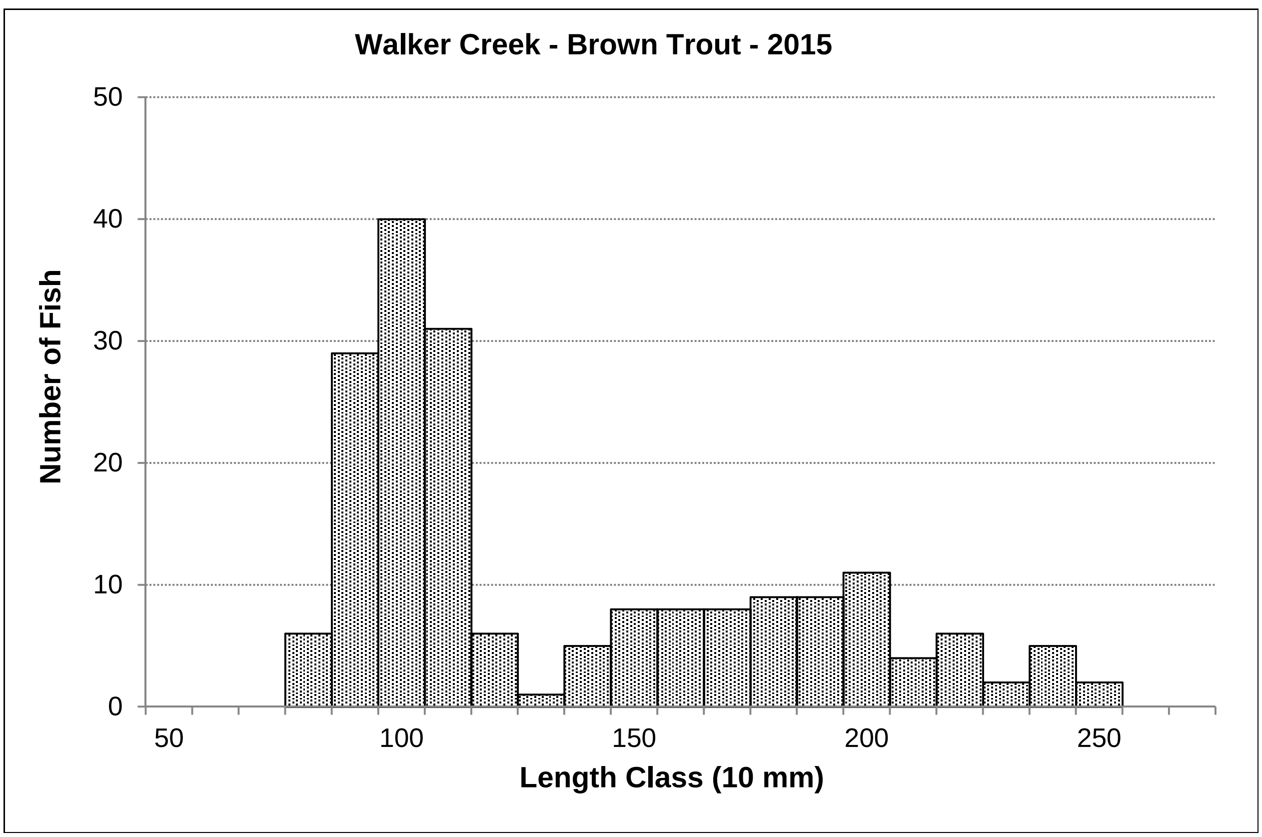

Figure 13. Length-frequency histogram of captured brown trout in Walker Creek, September 19th, 2015.

Table 3. Depletion estimates made in the side channel section of Lee Vining Creek and Walker Creek during September 2015 showing number of trout captured in each pass, estimated number, probability of capture (P.C.) by species and size class.

Stream - Section Date / **Species**	Size Class (mm)	Removals	Removal Pattern	**Estimate**	P.C.
Lee Vining Creek- Side Channel - 9/19/2015					
Brown Trout					
	0 - 124 mm	2	0 0	**0**	1.00
	125 - 199 mm	2	7 0	**7**	1.00
	200 + mm	2	0 0	**0**	1.00
Walker Creek - above old Hwy 395 - 9/19/2015					
Brown Trout					
	0 - 124 mm	2	103 9	**112**	0.93
	125 - 199 mm	2	55 4	**59**	0.94
	200 + mm	2	18 1	**19**	0.95

Catch of Rainbow Trout in Rush and Lee Vining Creeks

Beginning with the 2008 annual report, rainbow trout catch numbers have largely been reported for Rush Creek. This decision was made because rainbow trout usually accounted for <5% of the total catch in Rush Creek. In 2011 GLR spilled, carrying hatchery-origin rainbow trout out of the reservoir resulting in rainbow trout accounting for 8% of the total catch in 2011, the highest ever sampled in Rush Creek. In 2012, rainbow trout accounted for 5% of the total catch in Rush Creek. Although there were only 10 fewer rainbow trout captured in 2012 compared to 2011 the total number of trout in Rush Creek captured increased from 3,352 trout in 2011 to 4,697 in 2012 thus driving down the percent-catch of rainbow trout. In 2013, the rainbow trout catch in Rush Creek was down to 66 fish versus 3,035 brown trout, thus rainbow trout comprised 2% of the trout captured (66 rainbow trout/3,101 total trout). In 2014, rainbow trout comprised 0.75% of the Rush Creek catch (15 rainbow trout/1,996 total trout). In 2015, rainbow trout comprised 1.9% of the trout captured (38 rainbow trout/1,925 total trout). Given the California Department of Fish and Wildlife (CDFW) current policy of stocking sterile catchable rainbow trout, it is unlikely that future rainbow trout numbers will approach 5% of the total fish catch in Rush Creek unless another major spill occurs from GLR during a wet RY.

Between 1999 and 2012 rainbow trout numbers in Lee Vining Creek were variable, generally higher during drier RY types and lower during wetter years. However, since 2012 the annual catch of rainbow trout in Lee Vining Creek has dropped steadily and dramatically. In 2012, a total of 235 rainbow trout were captured, including 226 age-0 fish. In 2013, 127 rainbow trout were captured (26 were age-0 fish), followed by 57 rainbows in 2014 (six were age-0 fish) and 20 rainbows in 2015 (no age-0 fish). This dramatic drop in rainbow trout numbers has occurred during the four consecutive dry water years, which is worrisome since rainbow trout (as spring spawners) have typically flourished in drier years when peak flows were too small to mobilize the channel bed and disrupt incubating eggs or alevins. This large drop in rainbow trout numbers has also occurred during the time period when CDFW has been stocking sterile catchable rainbow trout, which suggests that in past years successful spawning by hold-over rainbow trout may have, to a large degree, supported the Lee Vining Creek population.

Sufficient numbers of age-0 rainbow trout were captured in the main channel to generate population estimates for only four of the 15 years sampled (Table 4). Adequate numbers of age-1 and older rainbow trout were captured in the main channel to generate population estimates seven of the 15 years sampled (Table 5). The side channel produced enough numbers of age-0 and age-1 and older rainbow trout to generate population estimates for six of the 16 years sampled (Tables 6 and 7). However, no age-0 rainbow trout have been caught in the side channel in the past seven years and no age-1 and older rainbows have been caught in the past five years (Tables 6 and 7).

Due to rainbow trout historically encompassing a large portion (10-40%) of the Lee Vining Creek fishery, an effort has been made to generate density and biomass values using all data available. In years when adequate numbers of rainbows have been captured, statistically valid density and biomass estimates have been generated. In years when less than adequate numbers of rainbow trout have been captured, catch numbers have been used to generate density and biomass estimates. While catch numbers are not statistically valid they are consistently lower than statistically valid estimates and allow for comparison between sampling years (Tables 4-7).

Table 4. Numbers of age-0 rainbow trout caught in Lee Vining Creek main channel section, 2000-2015.

Sample Year	Area of Sample Section (Ha)	Number of Trout on Marking Run	Number of Trout on Capture Run	Number of Recap Trout	Pop Estimate	Estimated Number of Trout per Hectare	Number of Trout Caught (Catch)	Catch per Hectare
2015	**0.1224**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2014	0.1403	4	4	2	NP	NP	6	43
2013	0.1454	19	12	5	40	275	26	179
2012	0.1279	155	138	67	318	2,494	226	1,773
2011	0.1428	1	0	0	NP	NP	1	7
2010	0.1505	0	0	0	0	0	0	0
2009	0.1505	4	4	0	NP	NP	8	53

Table 4 (continued). Numbers of age-0 rainbow trout caught in Lee Vining Creek main channel section, 2000-2015.

Sample Year	Area of Sample Section (Ha)	Number of Trout on Marking Run	Number of Trout on Capture Run	Number of Recap Trout	Pop Estimate	Estimated Number of Trout per Hectare	Number of Trout Caught (Catch	Catch per Hectare
2008	0.1377	17	31	9	57	414	39	283
2007	0.0884	42	56	22	106	1,199	76	860
2006	NS*	--	--	--	--	--	--	--
2005	0.0744	0	0	0	0	0	0	0
2004	0.0744	1	0	0	NP	NP	1	13
2003	0.0744	0	0	0	0	0	0	0
2002	0.0744	0	1	0	NP	NP	1	13
2001	0.0898	3	5	1	NP	NP	7	78
2000	0.0898	0	1	0	NP	NP	1	22

*NS stands for not sampled due to high flows

Table 5. Numbers of age-1 and older rainbow trout caught in Lee Vining Creek main channel section, 2000-2015.

Sample Year	Area of Sample Section (Ha)	Number of Trout on Marking Run	Number of Trout on Capture Run	Number of Recap Trout	Pop Estimate	Estimated Number of Trout per Hectare	Number of Trout Caught (Catch)	Catch per Hectare
2015	**0.1224**	**18**	**14**	**12**	**21**	**172**	**20**	**163**
2014	0.1403	36	36	21	63	449	51	364
2013	0.1454	61	45	29	120	826	77	530
2012	0.1279	7	7	5	NP	NP	9	71
2011	0.1428	5	8	5	NP	NP	8	56
2010	0.1505	12	9	7	15	100	14	93
2009	0.1505	39	32	12	98	651	59	392
2008	0.1377	71	64	37	129	936	98	712
2007	0.0884	3	5	1	NP	NP	7	79
2006	NS*	--	--	--	--	--	--	--
2005	0.0744	3	3	0	NP	NP	6	81
2004	0.0744	2	2	2	NP	NP	2	27
2003	0.0744	5	6	5	NP	NP	6	81
2002	0.0744	10	10	7	14	188	13	175
2001	0.0898	9	8	4	NP	NP	13	145
2000	0.0898	1	3	0	NP	NP	4	45

*NS stands for not sampled due to high flows

Table 6. Numbers of age-0 rainbow trout caught in Lee Vining Creek side channel section, 2000-2015.

Sample Year	Area of Sample Section (Ha)	Number of Trout Caught on Pass #1	Number of Trout Caught on Pass #2	Number of Trout Caught on Pass #3	Pop Estimate	Estimated Number of Trout per Hectare	Number of Trout Caught (Catch)	Catch per Hectare
2015	**0.1224**	**0**	**0**	**--**	**0**	**0**	**0**	**0**
2014	0.0191	0	0	--	0	0	0	0
2013	0.0195	0	0	--	0	0	0	0
2012	0.0365	0	0	--	0	0	0	0
2011	0.0507	0	0	--	0	0	0	0
2010	0.0507	0	0	--	0	0	0	0
2009	0.0488	0	0	--	0	0	0	0
2008	0.0488	5	2	--	7	143	7	143
2007	0.0488	4	0	--	NP	NP	4	82
2006	0.0761	46	26	--	100	1,314	72	946
2005	0.0936	0	0	--	0	0	0	0
2004	0.0936	82	30	--	127	1,357	112	1,197
2003	0.0936	0	0	--	0	0	0	0
2002	0.0936	28	17	--	64	684	45	481
2001	0.1310	69	23	--	102	779	92	702
2000	0.0945	32	15	--	57	603	47	497

Table 7. Numbers of age-1 and older rainbow trout caught in Lee Vining Creek side channel section, 2000-2015.

Sample Year	Area of Sample Section (Ha)	Number of Trout Caught on Pass #1	Number of Trout Caught on Pass #2	Number of Trout Caught on Pass #3	Pop Estimate	Estimated Number of Trout per Hectare	Number of Trout Caught (Catch)	Catch per Hectare
2015	**0.1224**	**0**	**0**	**--**	**0**	**0**	**0**	**0**
2014	0.0191	0	0	--	0	0	0	0
2013	0.0195	0	0	--	0	0	0	0
2012	0.0365	0	0	--	0	0	0	0
2011	0.0507	0	0	--	0	0	0	0
2010	0.0507	1	0	--	1	20	1	20
2009	0.0488	15	0	--	15	307	15	307
2008	0.0488	3	1	--	4	82	4	82
2007	0.0488	6	0	--	NP	NP	6	123
2006	0.0761	5	0	--	NP	NP	5	66
2005	0.0936	7	2	--	9	96	9	96
2004	0.0936	5	0	--	NP	NP	5	53
2003	0.0936	13	0	--	NP	NP	13	139
2002	0.0936	29	4	--	33	353	33	353
2001	0.1310	38	3	--	41	313	41	313
2000	0.0945	9	0	--	NP	NP	9	95

Relative Condition of Brown Trout

After Log_{10} transformations were performed on the lengths and weights of captured brown trout ≥ 100 mm, and a simple linear regression analysis was then performed. All sections had r^2 values 0.98 or greater, indicating that length was strongly correlated with weight (Table 8).

Table 8. Regression statistics for log_{10} transformed length (L) to weight (WT) for brown trout 100 mm and longer captured in Rush Creek by sample section and year. The 2015 regression equations are in ***bold*** type.

Section	Year	N	Equation	r^2	P
Bottomlands	***2015***	***301***	***$Log_{10}(WT) = 3.0748*Log_{10}(L) – 5.1916$***	***0.99***	***<0.01***
	2014	238	$Log_{10}(WT) = 3.0072*Log_{10}(L) – 5.0334$	0.98	<0.01
	2013	247	$Log_{10}(WT) = 2.7997*Log_{10}(L) – 4.591$	0.98	<0.01
	2012	495	$Log_{10}(WT) = 2.8149*Log_{10}(L) – 4.6206$	0.98	<0.01
	2011	361	$Log_{10}(WT) = 2.926*Log_{10}(L) – 4.858$	0.99	<0.01
	2010	425	$Log_{10}(WT) = 2.999*Log_{10}(L) – 5.005$	0.99	<0.01
	2009	511	$Log_{10}(WT) = 2.920*Log_{10}(L) – 4.821$	0.99	<0.01
	2008	611	$Log_{10}(WT) = 2.773*Log_{10}(L) – 4.524$	0.99	<0.01
Upper Rush	***2015***	***643***	***$Log_{10}(WT) = 2.9444*Log_{10}(L) – 4.8844$***	***0.99***	***<0.01***
	2014	613	$Log_{10}(WT) = 2.9399*Log_{10}(L) – 4.8705$	0.99	<0.01
	2013	522	$Log_{10}(WT) = 2.9114*Log_{10}(L) – 4.816$	0.99	<0.01
	2012	554	$Log_{10}(WT) = 2.8693*Log_{10}(L) – 4.721$	0.99	<0.01
	2011	547	$Log_{10}(WT) = 3.006*Log_{10}(L) – 5.014$	0.99	<0.01
	2010	420	$Log_{10}(WT) = 2.995*Log_{10}(L) – 4.994$	0.99	<0.01
	2009	612	$Log_{10}(WT) = 2.941*Log_{10}(L) – 4.855$	0.99	<0.01
	2008	594	$Log_{10}(WT) = 2.967*Log_{10}(L) – 4.937$	0.99	<0.01
	2007	436	$Log_{10}(WT) = 2.867*Log_{10}(L) – 4.715$	0.99	<0.01
	2006	485	$Log_{10}(WT) = 2.99*Log_{10}(L) – 4.98$	0.99	<0.01
	2005	261	$Log_{10}(WT) = 3.02*Log_{10}(L) – 5.02$	0.99	<0.01
	2004	400	$Log_{10}(WT) = 2.97*Log_{10}(L) – 4.94$	0.99	<0.01
	2003	569	$Log_{10}(WT) = 2.96*Log_{10}(L) – 4.89$	0.99	<0.01
	2002	373	$Log_{10}(WT) = 2.94*Log_{10}(L) – 4.86$	0.99	< 0.01
	2001	335	$Log_{10}(WT) = 2.99*Log_{10}(L) – 4.96$	0.99	< 0.01
	2000	309	$Log_{10}(WT) = 3.00*Log_{10}(L) – 4.96$	0.98	< 0.01
	1999	317	$Log_{10}(WT) = 2.93*Log_{10}(L) – 4.84$	0.98	< 0.01

Table 8 (continued).

Section	Year	N	Equation	R^2	P
MGORD	***2015***	***172***	**$Log_{10}(WT) = 3.131*Log_{10}(L) – 5.3093$**	**0.99**	**<0.01**
	2014	399	$Log_{10}(WT) = 2.9805*Log_{10}(L) – 4.9827$	0.98	<0.01
	2013	431	$Log_{10}(WT) = 2.8567*Log_{10}(L) – 4.692$	0.98	<0.01
	2012	795	$Log_{10}(WT) = 2.9048*Log_{10}(L) – 4.808$	0.99	<0.01
	2011	218	$Log_{10}(WT) = 2.917*Log_{10}(L) – 4.823$	0.98	<0.01
	2010	694	$Log_{10}(WT) = 2.892*Log_{10}(L) – 4.756$	0.98	<0.01
	2009	689	$Log_{10}(WT) = 2.974*Log_{10}(L) – 4.933$	0.99	<0.01
	2008	862	$Log_{10}(WT) = 2.827*Log_{10}(L) – 4.602$	0.98	<0.01
	2007	643	$Log_{10}(WT) = 2.914*Log_{10}(L) – 4.825$	0.98	<0.01
	2006	593	$Log_{10}(WT) = 2.956*Log_{10}(L) – 4.872$	0.98	<0.01
	2004	449	$Log_{10}(WT) = 2.984*Log_{10}(L) – 4.973$	0.99	<0.01
	2001	769	$Log_{10}(WT) = 2.873*Log_{10}(L) – 4.719$	0.99	<0.01
	2000	82	$Log_{10}(WT) = 2.909*Log_{10}(L) – 4.733$	0.98	<0.01

Condition factors of brown trout 150 to 250 mm in length in 2015 decreased in two sections (Upper Rush and Walker) from 2014’s values, increased in three sections from 2014’s values (MGORD, Lee Vining side channel, and Lee Vining main channel), and stayed the same in one section (Rush Bottomlands) (Figure 14). In 2015, no sections had brown trout condition factors ≥1.00 (Figure 14).

The Upper Rush section had a condition factor of 0.97 in 2015, a slight decrease from 0.99 in 2014 (Figure 14). The lowest condition factor value in the 15-year sampling history was 0.96 in 2007 and the value has been less than 1.00 for the four consecutive dry years.

The Bottomlands section had a condition factor of 0.96 in 2015, the same value as in 2014, which was an increase from 0.91 in 2013 (Figure 14). In eight years of sampling, the Bottomlands section has failed to generate a brown trout condition factor ≥1.00 (Figure 14).

The MGORD’s 2015 condition factor was 0.97, a slight increase from the 2014 value of 0.94. For six consecutive years, the condition factor of brown trout 150 to 250 mm in length has been less than average (Figure 14).

For the third consecutive year, brown trout in Lee Vining Creek’s main channel had a condition factor below 1.00 (Figure 14). The 2015 value was 0.94, up slightly from 2014’s value of 0.93 (Figure 14). For the past three years, rainbow trout 150 to 250 mm in length from the main channel also had a condition factor of less than 1.00 (Figure 15). Rainbow trout in 2015 once again had a better condition factor than the brown trout (0.98 versus 0.94) in the main channel section of Lee Vining Creek (Figure 15).

In 2015, brown trout in Lee Vining Creek's side channel had a condition factor 0.90, a slight increase from 2014's value of 0.89 (Figure 14). This was the third consecutive year in the 15 years of sampling the side channel that condition factors were less than 1.00. For the fifth year in a row, no rainbow trout were captured in the Lee Vining Creek side channel.

In Walker Creek, brown trout had a condition factor of 0.98 in 2015, a slight decrease from 1.00 in 2014 (Figure 14).

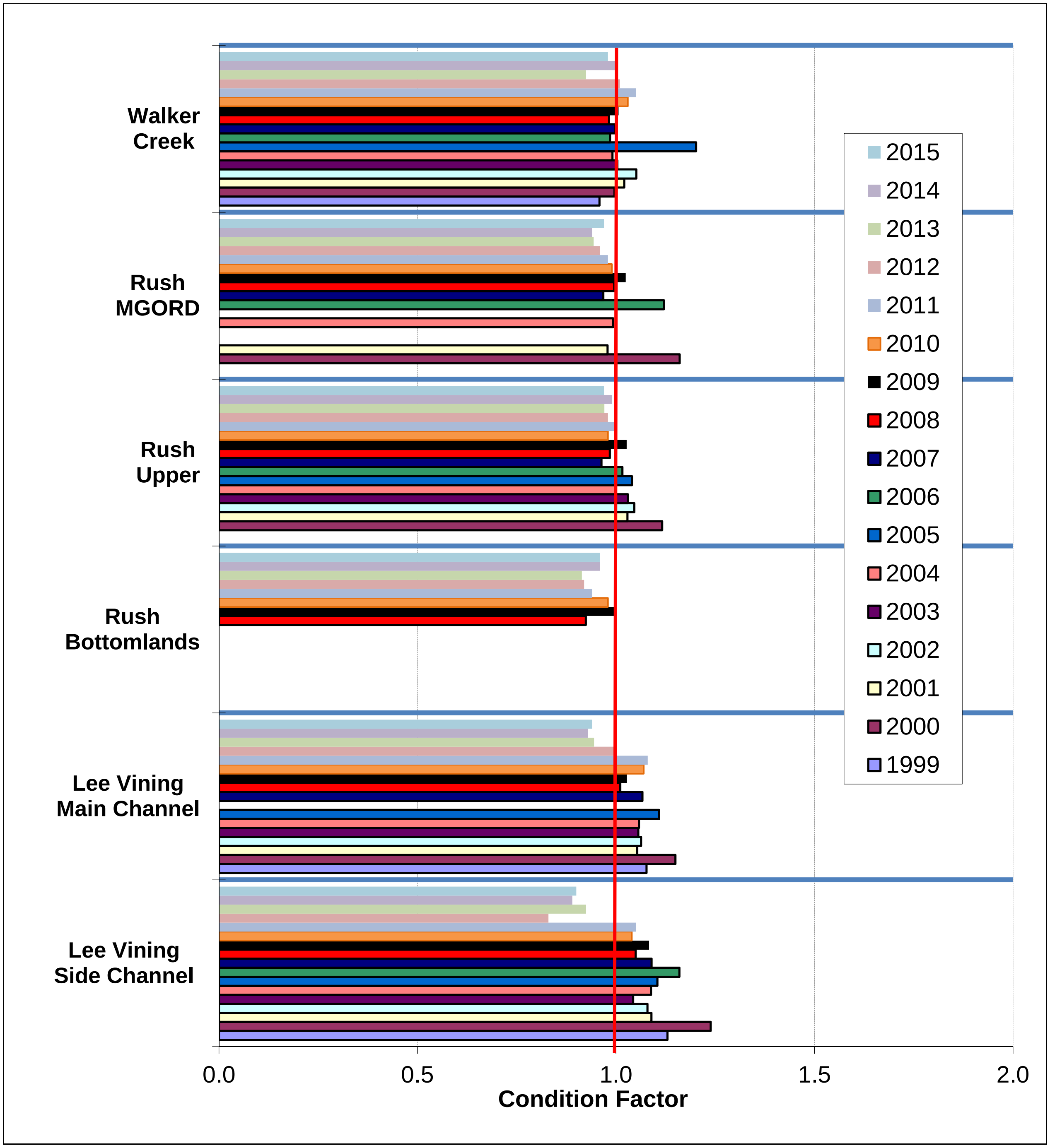

Figure 14. Condition factors for brown trout 150 to 250 mm in length from sample sections of Rush, Lee Vining, and Walker Creeks from 1999 to 2015.

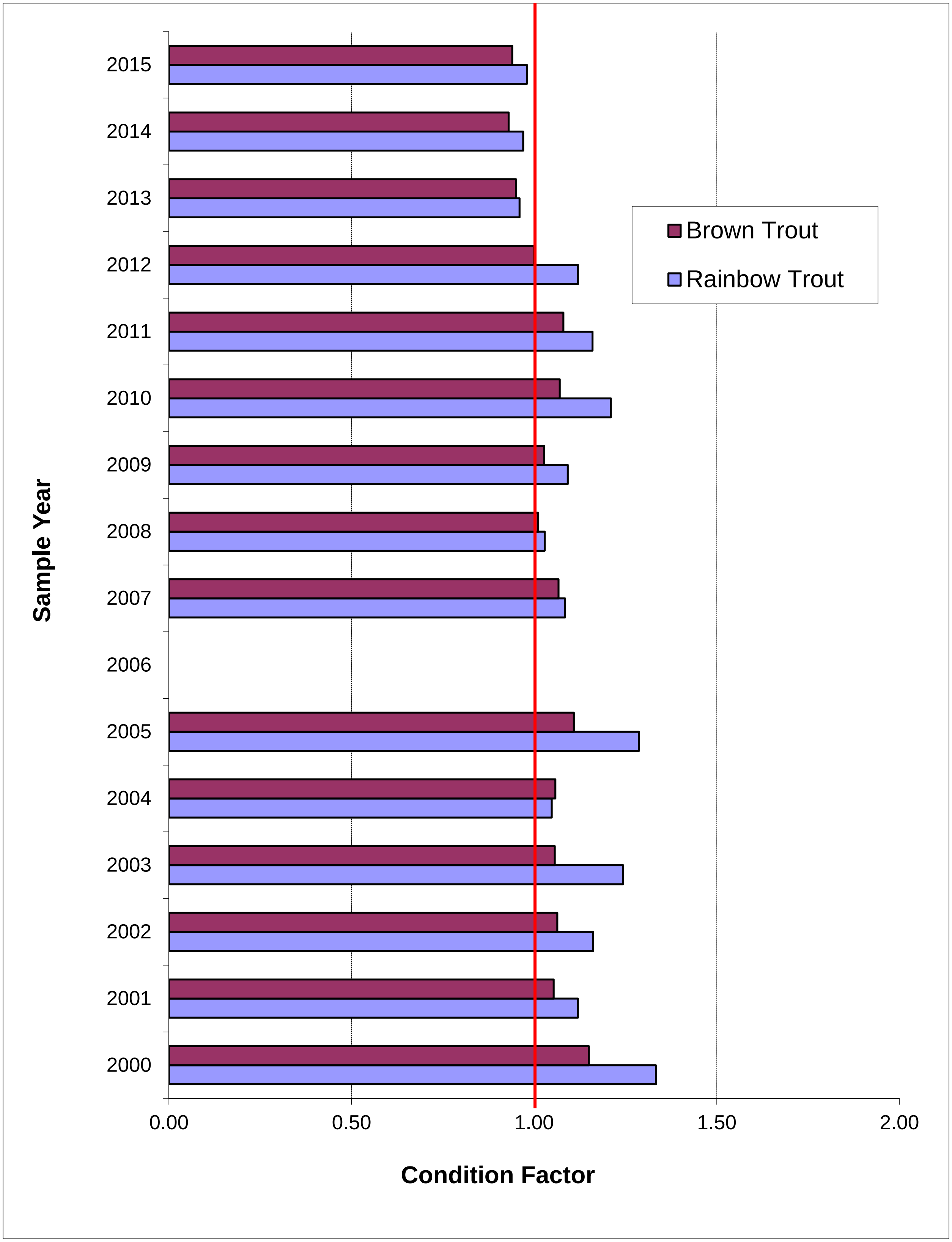

Figure 15. Comparison of condition factors for rainbow trout and brown trout 150 to 250 mm in length from the main channel section of Lee Vining Creek from 2000 to 2015. Main channel was not sampled in 2006 due to high flows.

Estimated Trout Densities

Age-0 Brown Trout

The Upper Rush section had an estimated density of 2,061 age-0 brown trout/ha in 2015, a decrease of 52% from 2014's estimate of 4,228 age-0 trout/ha and a 65% decrease from 2013's estimate of 5,733 age-0 trout/ha (Figure 16). Between 2012 and 2015 (the four consecutive dry years), the age-0 brown trout density estimates dropped from 8,624 fish to 2,061 fish (a 76% decrease). The 2015 density value in the Upper Rush section was 67% lower than the 16-year average of 6,289 age-0 brown trout/ha.

The Bottomlands section of Rush Creek had a density estimate of 1,581 age-0 brown trout/ha in 2015. This estimate was a 178% increase in the number of age-0 trout/ha when compared to the 2014 estimate of 569 age-0 trout/ha (Figure 16). The three most recent estimates (2013-2015) were the lowest age-0 estimates since the start of sampling the Bottomlands section in 2008. When compared to the eight-year average of 2,083 age-0 brown trout/ha, the 2015 estimate was 24% lower.

In Walker Creek, the 2015 density estimate of 3,414 age-0 brown trout/ha was a 124% increase from the 2014 estimate of 1,527 age-0 trout/ha (Figure 16). The 2015 density estimate of 3,414 age-0 brown trout/ha was 4% lower than the 17-year average of 3,543 age-0 trout/ha (Figure 16).

In 2015, the age-0 brown trout density estimate in the main channel section of Lee Vining Creek was 2,051 age-0 trout/ha, which was a 19% increase from the 2014 density estimate of 1,726 age-0 trout/ha (Figure 17). The 2015 estimate was 17% higher than the 16-year average of 1,759 age-0 brown trout /ha.

No age-0 brown trout were captured in the Lee Vining Creek side channel during the 2015 sampling, the second consecutive year that no age-0 trout were sampled from the side channel (Figure 17). In 2013, only a single age-0 brown trout was captured in the Lee Vining Creek side channel (Figure 17).

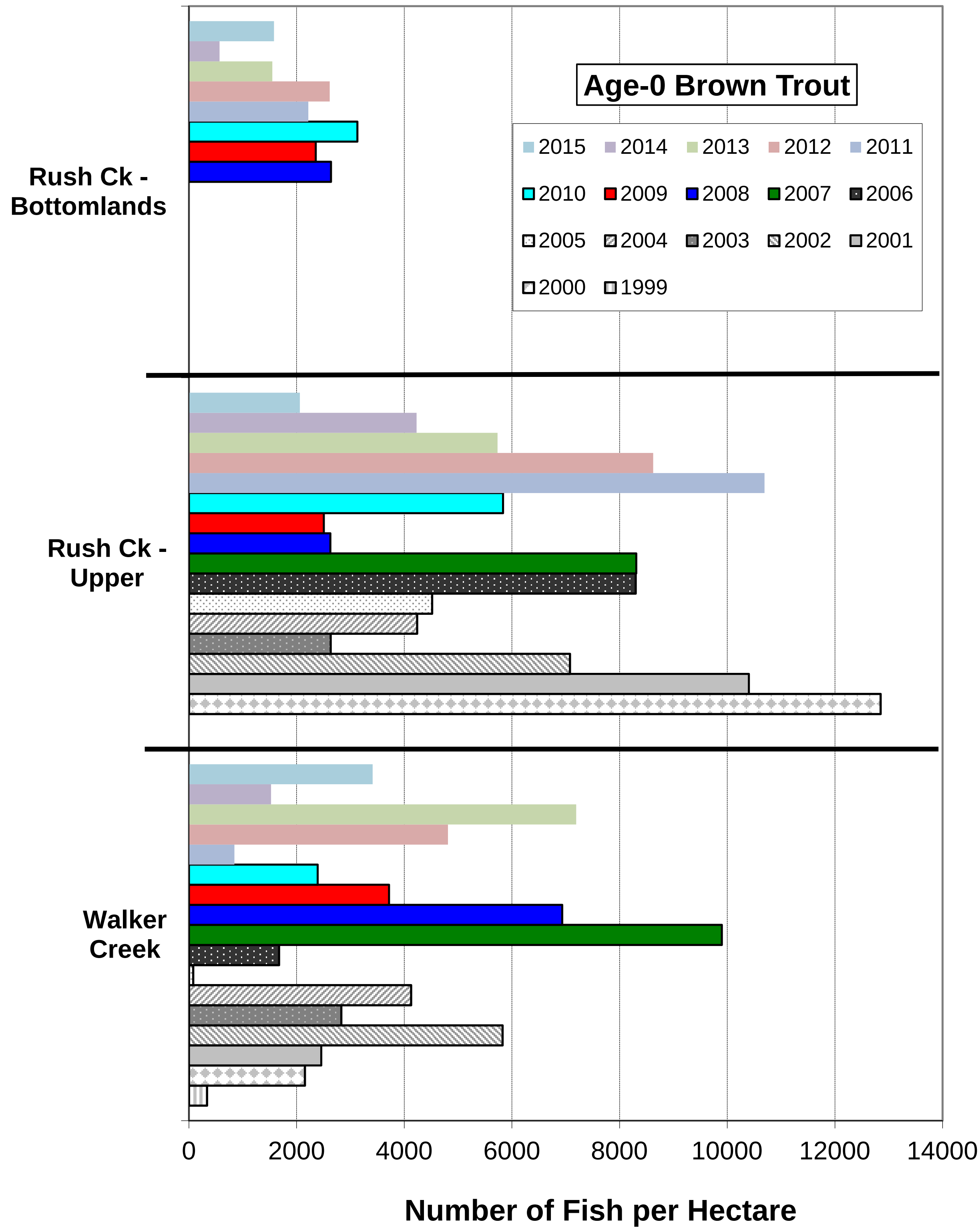

Figure 16. Estimated number of age-0 brown trout per hectare in Rush Creek and Walker Creek from 1999 to 2015.

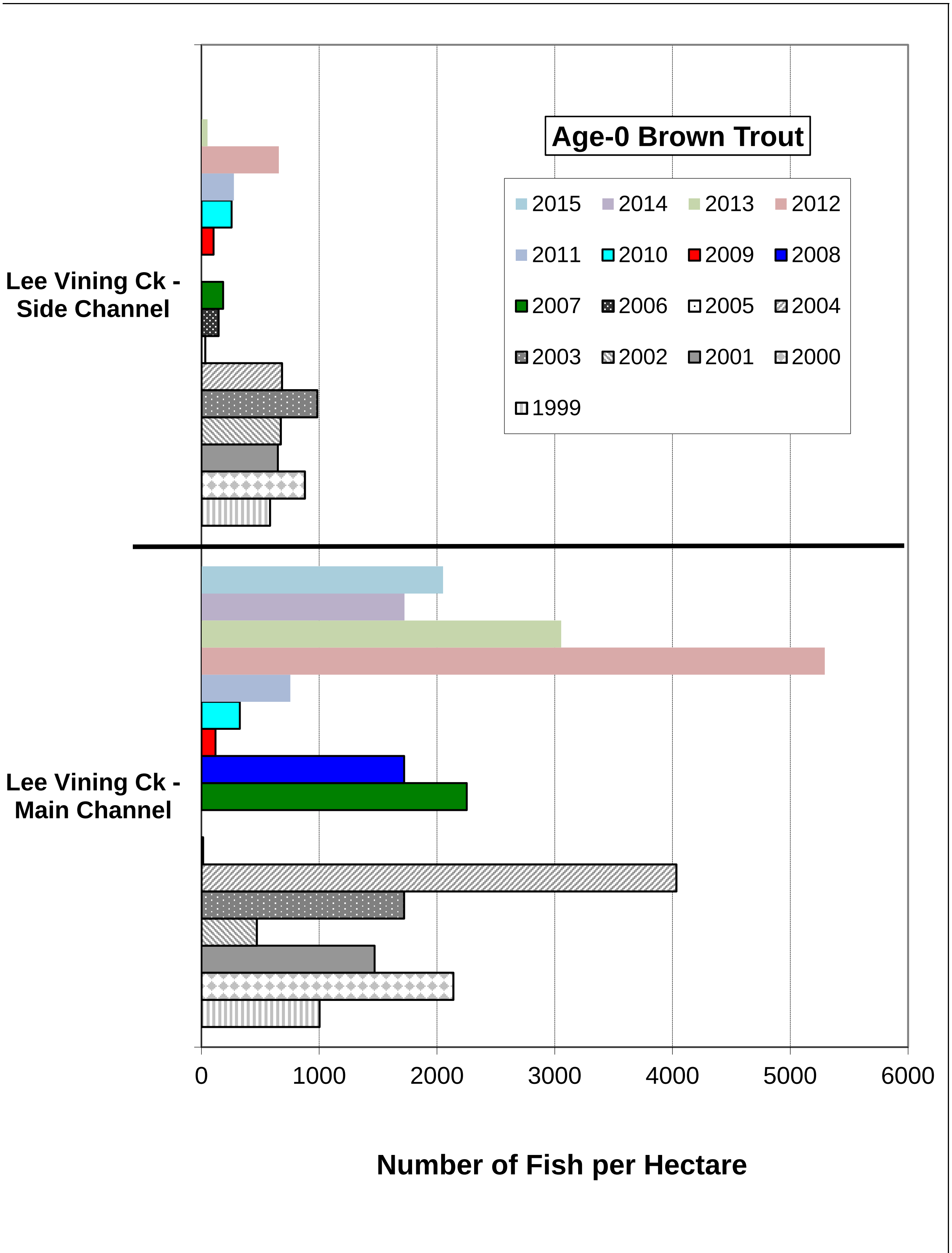

Figure 17. Estimated number of age-0 brown trout per hectare in Lee Vining Creek from 1999 to 2015.

Age-1 and older (aka Age-1+) Brown Trout

The Upper Rush section had an estimated density (number per hectare) of 1,319 age-1+ brown trout/ha in 2015, a decrease of 38% from the 2014 estimate of 2,125 trout/ha (Figure 18). The 2015 estimate was 11% lower than the 16-year average of 1,464 age-1+ brown trout /ha.

The Bottomlands section of Rush Creek produced a density estimate of 540 age-1+ brown trout/ha in 2015, a 46% decrease from the 2014 estimate of 1,000 age-1+trout/ha (Figure 18). The 2015 density estimate of age-1+ brown trout/ha was the lowest since the start of sampling the Bottomlands section in 2008 and was also the third consecutive decrease since 2012's estimate of 1,735 age-1+ trout/ha (Figure 18).

The 2015 density estimate for age-1+ brown trout for the Walker Creek section was 2,377 age-1+trout/ha which was a 36% decrease from the 2014 estimate of 3,736 age-1+ trout/ha (Figure 18). However, the 2015 density estimate of age-1+ brown trout was fourth highest estimate for the 17 years that Walker Creek has been sampled (Figure 18).

The 2015 density estimate for age-1+ brown trout in the Lee Vining main channel section was 2,002 trout/ha, a 10% decrease from the 2,225 age-1+ trout/ha in 2014 and a 18% decrease from the 2,449 age-1+ trout/ha in 2013 (Figure 19). The 2015 estimate was still the third highest density estimate of age-1+ brown trout for this section for the 16 seasons that estimates have been generated (main channel was not sampled in 2006 due to high flows) (Figure 19).

In 2015, the side channel of Lee Vining Creek produced an estimated density of 996 age-1+ brown trout/ha which was the highest estimate ever generated for this section, and a 58% increase from the 2014 estimate of 630 fish/ha (Figure 19). The 2015 estimate was generated from only seven trout captured, the fewest number of fish ever sampled in the Lee Vining Creek side channel. This relatively high density estimate was solely a function of the decreased area of wetted channel. Since the side channel started receiving a smaller proportion of Lee Vining Creek's total flow following the 2006 wet RY-type, the side channel's wetted area and total numbers of trout sampled remained fairly stable from 2007 through 2011 (Table 9). However, during the four consecutive dry RYs (2012 to 2015), the side channel's wetted surface area decreased from 365 m^2 to 70.3 m^2 (-81%) and the total numbers of trout captured also decreased by more than 80% (from 45 fish to seven fish) (Table 9). In this same period, the density estimate of age-1+ brown trout increased by 65% (Figure 19).

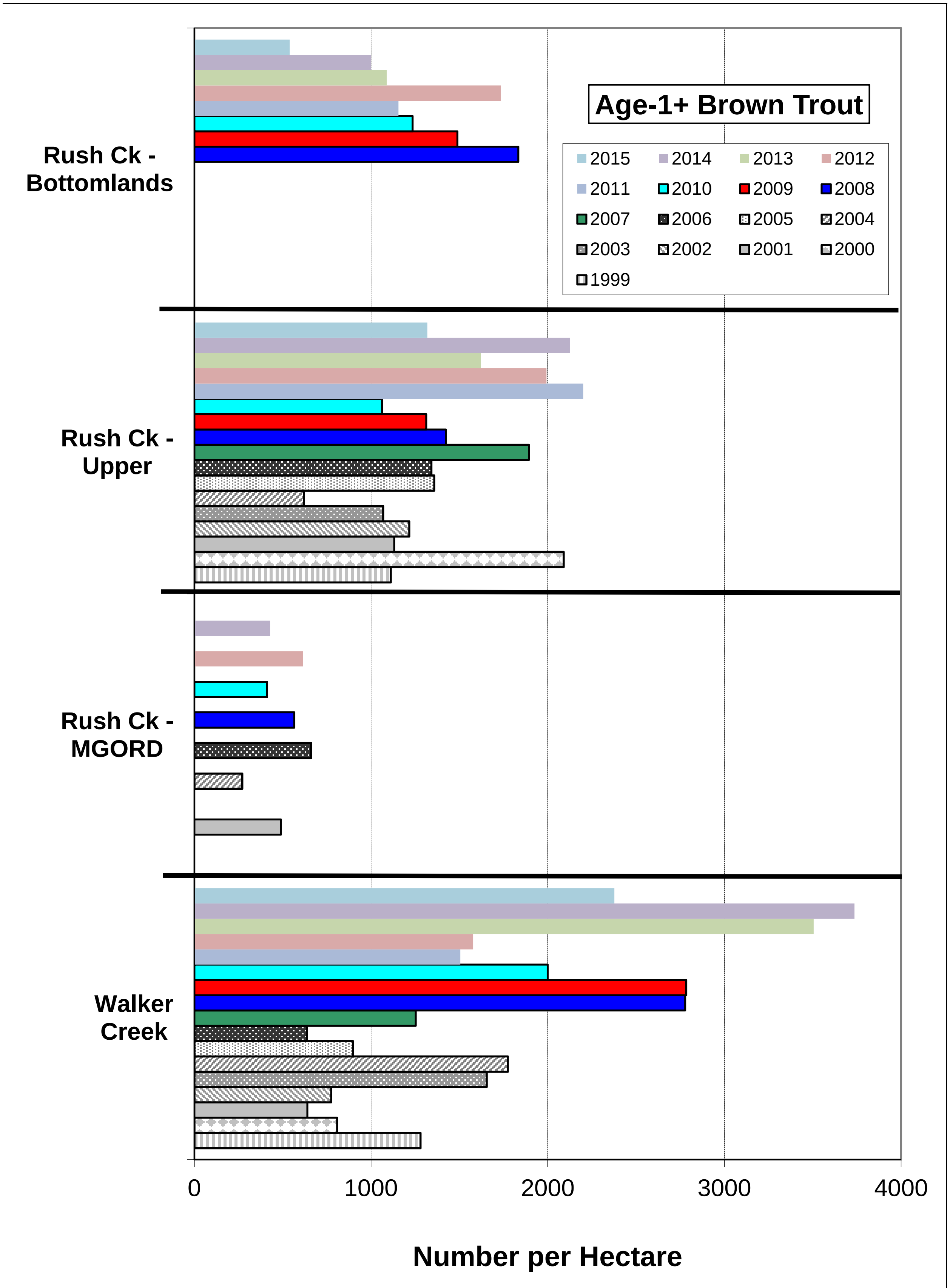

Figure 18. Estimated number of age-1 and older brown trout per hectare in sections of Rush and Walker Creeks from 1999 to 2014.

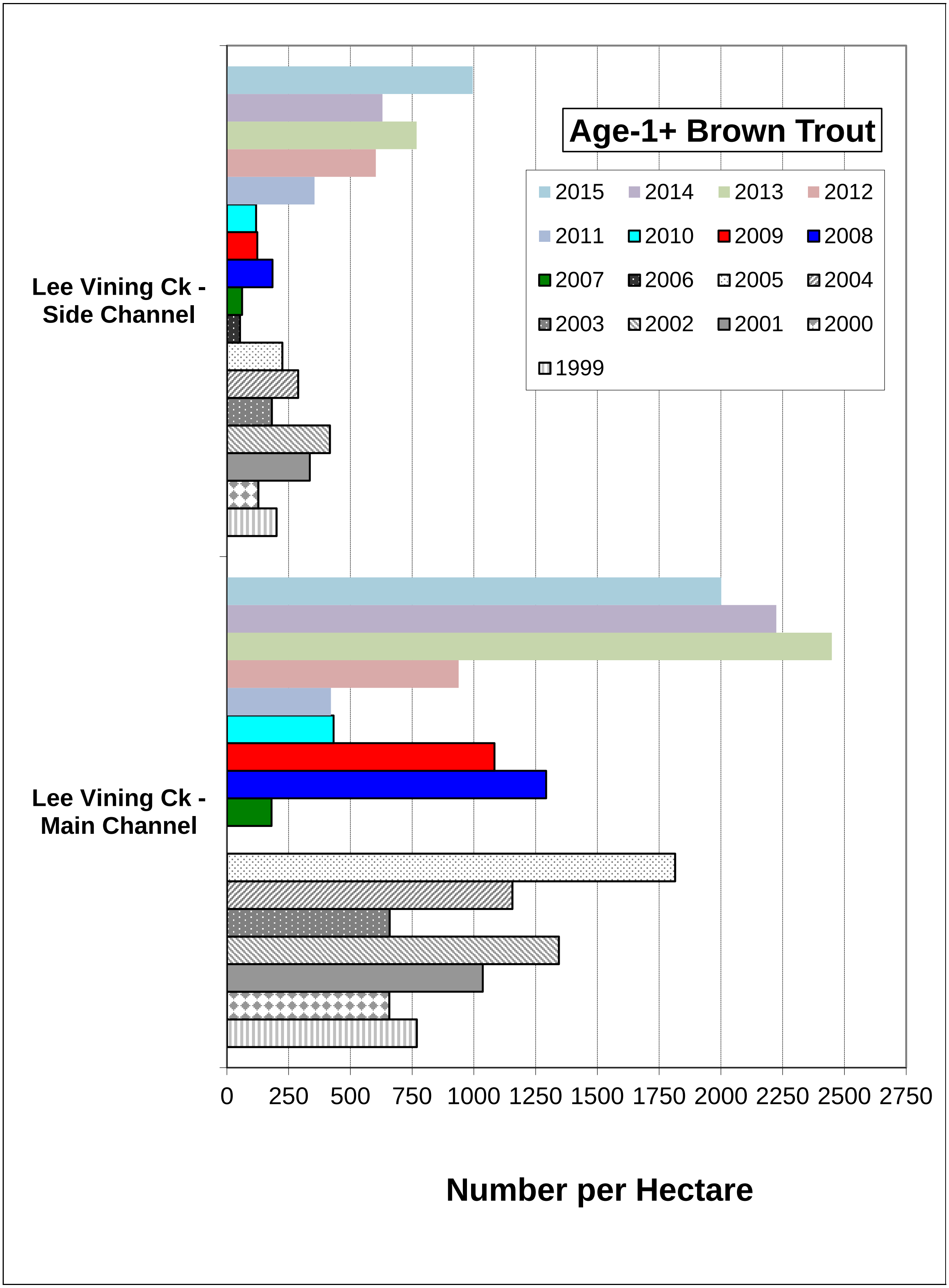

Figure 19. Estimated number of age-1 and older brown trout per hectare in sections of Lee Vining Creek from 1999 to 2015.

Table 9. Wetted surface area and total numbers of trout captured in the Lee Vining Creek side channel, from 2007 to 2015.

Sample Year	Wetted Channel Area (m^2)	Total Number of Trout Captured
2007	487.5	22
2008	487.5	20
2009	487.5	26
2010	507.0	20
2011	507.0	30
2012	365.0	45
2013	328.0	16
2014	190.5	12
2015	70.3	7

Age-0 Rainbow Trout

In 2015, for the seventh consecutive year no age-0 rainbow trout were captured in the Lee Vining Creek side channel.

In the Lee Vining Creek main channel, no age-0 rainbow trout were captured during the 2015 sampling. The last time that no age-0 rainbow trout were captured in Lee Vining Creek's main channel was in September of 2010, which was preceeded by a 500+ cfs peak flow in June of 2010.

Age-1 and older (aka Age-1+) Rainbow Trout

In 2015, for the fifth consecutive year no age-1 and older rainbow trout were captured in the Lee Vining Creek side channel.

For the Lee Vining Creek main channel, the estimated densities of age-1 and older rainbow trout decreased by 62% from 449 trout/ha in 2014 to 172 trout/ha in 2015 to (Figure 21). Between 2013 and 2015, the density estimate of age-1+ rainbow trout has decreased by 79%, from 826 fish/ha to 172 fish/ha (Figure 21). Sampling years (1999-2001, 2003-2005, 2007 and 2011) produced insufficient numbers of age-1 and older rainbow trout to generate population estimates, thus these density estimates were derived from catch data.

As previously mentioned (page 29), the numbers of rainbow trout captured in Lee Vining Creek have dropped dramatically since 2012, from 235 fish to 20 fish, a 91% decline during the four consecutive dry water-years.

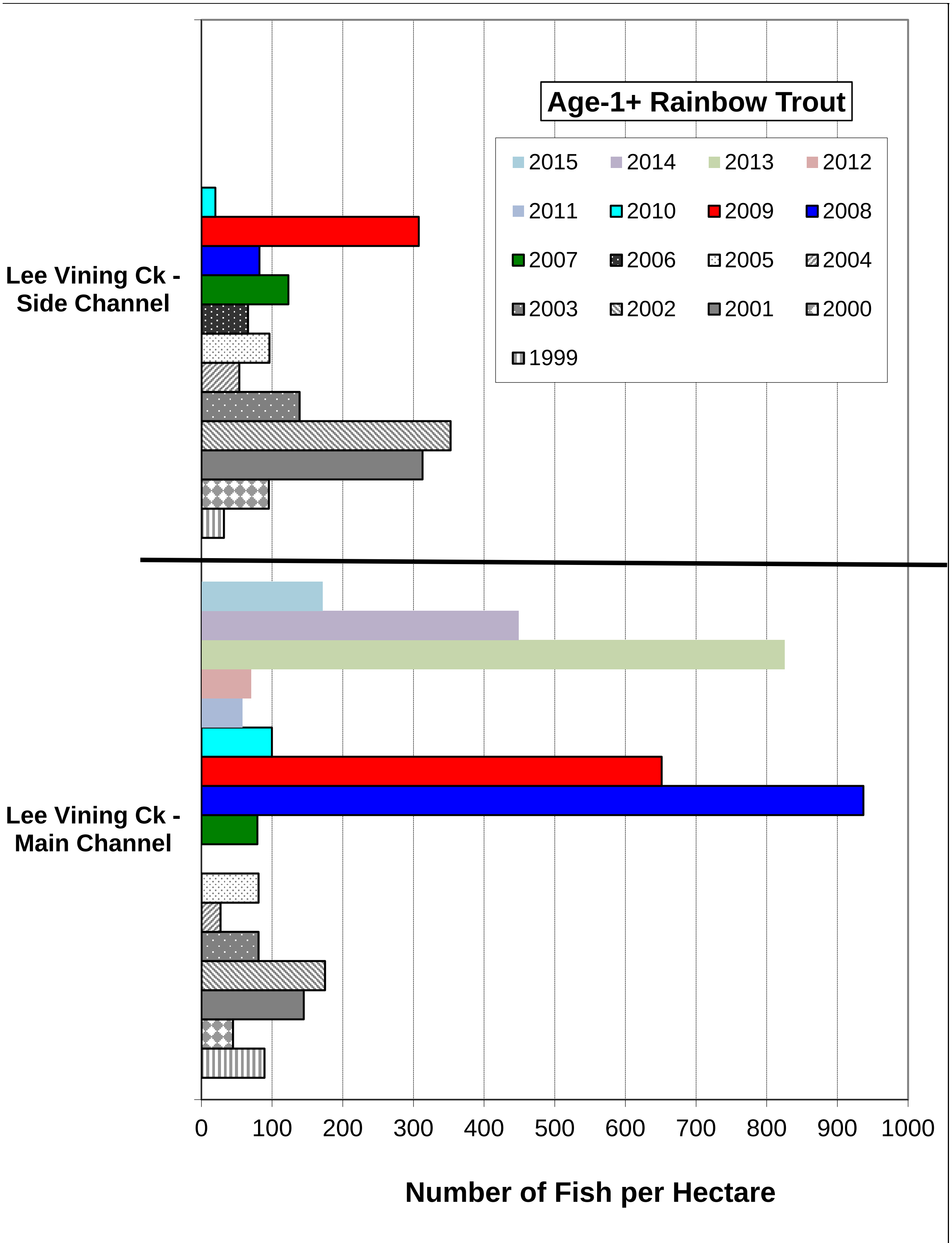

Figure 21. Estimated number of age-1 and older rainbow trout per hectare in sections of Lee Vining Creek from 1999 to 2015.

Estimated Trout Densities Expressed in Numbers per Unit Length

The Upper Rush section produced a total density estimate of 2,468 brown trout per kilometer which was a 46% decrease from the 2014 estimate of 4,574 brown trout per kilometer, and a 60% decrease from the 2013 estimate of 6,105 fish/km (Table 10). The estimated numbers of brown trout per kilometer have fallen for four straight years in the Upper Rush section (Table 10). In 2011, the year prior to the four consecutive dry years, the total density estimate was 10,821 brown trout per kilometer, thus the decrease over the four dry years was 77%. The estimated age-1+ brown trout density in 2015 was 963 fish/km which was a 37% decrease from the 2014 estimate of 1,530 fish/km (Table 10).

The Bottomlands section in in 2015 produced a total density estimate of 1,422 brown trout/km which was a 30% increase from the 2014 estimate of 1,098 fish/km (Table 10). This increase in total numbers of brown trout/km was due to the increased number of age-0 fish because the estimated density of age-1+ brown trout in 2015 was 362 fish/km, a 48% decrease from the 2014 estimate of 700 fish/km (Table 10). In 2015, the estimated number of age-1+ brown trout/km was the lowest estimate for the eight-year sampling period in the Bottomlands section.

The Lee Vining Creek main channel produced a total density estimate of 2,027 rainbow and brown trout/km in 2015 (Table 11). The 2015 estimate was 17% less than the 2014 estimate of 2,444 rainbow trout and brown trout/km (Table 11). After the peak estimate of 4,361 fish/km in 2012 (the first of four consecutive dry years), the estimate has decreased each subsequent year, and 2015's estimate was 54% less than 2012's estimate. For age-1+ rainbow trout and brown trout combined, the estimated density was 1,043 fish/km in 2015, which was a 29% decrease from the 2014 estimate of 1,471 age-1+ fish/km (Table 11).

The Lee Vining side channel produced a total density estimate of 95 brown trout/km in 2014, a 27% decrease from the 2013 estimate of 131 fish/km (Table 11). For age-1+ brown trout, the 2014 density estimate was also 95 brown trout/km which was a 23% decrease from the 2013 density estimate 123 fish/km (Table 11).

The Lee Vining Creek main channel and the side channel densities were added in order to compare to the proposed termination criteria as discussed in the 2011 Annual Fisheries Report (Taylor and Knudson 2011). When combined, the two channels produced a total density estimate of 1,591 rainbow and brown trout/km in 2015, a decrease of 4% from the 2014 estimate of 1,662 and a 39% decrease from the 2013 estimate of 2,588 rainbow and brown trout/km (Table 11). Age-1+ trout in these two channels produced an estimate of 819 rainbow and brown trout/km in 2015, a 19% decrease from 1,013 rainbow and brown trout/km in 2014, and a 37% decrease from the 2013 estimate of 1,302 fish/km (Table 11).

Table 10. Total number of brown trout per kilometer of stream channel for Rush Creek sample sections from 2000 to 2015. The value within (#) denotes the number of age-1 and older trout per kilometer.

Collection Location	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Rush Creek, Upper Rush	11,054 (1,547)	8,535 (837)	6,137 (900)	2,740 (791)	3,881 (495)	5,032 (1,167)	7,905 (1,100)	8,698 (1,621)	3,607 (1,267)	3,444 (1,186)	5,726 (881)	10,821 (1,833)	8,288 (1,556)	6,105 (1,347)	4,574 (1,530)	**2,468 (963)**
Rush Creek, Bottom-lands	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,579 (1,467)	2,961 (1,146)	3,405 (963)	2,725 (929)	3,208 (1,279)	1,980 (817)	1,098 (700)	**1,422 (362)**

Table 11. Total number of brown and rainbow trout per kilometer of stream channel for Lee Vining Creek sample sections from 2000 to 2015. The value within (#) denotes the number of age-1 and older trout per kilometer.

Collection Location	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Lee Vining, Main Channel	674 (337)	1,333 (567)	883 (729)	1,181 (355)	936 (568)	917 (910)	No Sample due to high flow	2,103 (148)	2,357 (1,204)	1,192 (1,023)	518 (326)	727 (258)	4,361 (506)	3,765 (1,867)	2,444 (1,471)	**2,027** (**1,043**)
Lee Vining, Side Channel	853 (112)	623 (287)	731 (369)	626 (154)	1,144 (165)	169 (154)	618 (48)	129 (62)	103 (67)	133 (108)	103 (36)	159 (87)	257 (123)	131 (123)	95 (95)	**100 (100)**
LV Main + LV Side Additive Approach	764 (225)	978 (427)	807 (549)	904 (255)	1,040 (367)	543 (532)	N/A	1,116 (105)	1,230 (636)	663 (566)	311 (181)	443 (173)	2,668 (348)	2,588 (1,302)	1,662 (1,013)	**1,591 (819)**

Estimated Trout Standing Crop Comparisons

The estimated standing crop for brown trout in the Upper Rush section was 123 kg/ha in 2015, a 26% decrease from the 2014 estimate of 167 kg/ha (Table 12 and Figure 22). Since the record high estimate of 224 kg/ha in 2011, the standing crop of brown trout in the Upper Rush section has generally declined in the subsequent four consecutive dry years (Figure 22). When compared to the 17-year average of 150 kg/ha, the 2015 standing crop estimate was approximately 18% greater (Figure 22).

The estimated standing crop for brown trout in the Bottomlands section of Rush Creek was 59 kg/ha in 2015; a 13% increase from 52 kg/ha in 2014 (Table 12 and Figure 22). When compared to the eight-year average of 89 kg/ha, the 2015 standing crop estimate was approximately 34% lower (Figure 22).

Although there is not a standing crop termination criterion for Walker Creek, an estimate was still generated for this annually-sampled section. The estimated standing crop for brown trout in Walker Creek was 183 kg/ha in 2015, a 3% decrease from the 2014 estimate of 189 kg/ha (Table 12 and Figure 22). The 2015 standing crop estimate was the fourth highest value recorded in Walker Creek over the 17-year sample period and the long-term average for this period is 132 kg/ha.

The Lee Vining Creek main channel in 2015 produced a total standing crop of 150 kg/ha for both rainbow and brown trout (Table 13 and Figure 23). The 2015 total estimate was a 7% increase from the 2014 estimate of 140 kg/ha (Table 13). The 2015 brown trout standing crop estimate was 138 kg/ha and the rainbow trout standing crop estimate was 12 kg/ha. In 2015, the brown trout estimated standing crop increased from the 2014 estimate by 22% and the 2015 rainbow trout estimated standing crop decreased by 51% from the 2014 estimate. Between 2013 and 2015, the rainbow trout estimated standing crop has decreased by 75%. The 2015 total standing crop of 150 kg/ha was 18 kg/ha greater than the 16-year average of 132 kg/ha.

The Lee Vining Creek side channel produced a brown trout standing crop estimate of 45 kg/ha in 2015 which was a 50% increase from 2014's estimate of 30 kg/ha and a 73% increase from 2013's estimate of 26 kg/ha (Table 13 and Figure 23). These increased standing crop estimates within the side channel were due to the recent declines in wetted surface area as previously described (Table 9). No rainbow trout were captured in the Lee Vining Creek side channel in 2015 and none have been sampled in the side channel section for five consecutive years (2011-2015).

When an additive standing crop estimate was generated for the Lee Vining Creek main channel and the side channel, the total standing crop estimate equaled 145 kg/ha for 2015, a 15% increase from the 2014 estimate of 126 kg/ha (Table 13).

Table 12. Comparison of brown trout standing crop (kg/ha) estimates between 2012, 2013, 2014 and 2015 for Rush Creek sections.

Collection Location	2012 Total Standing Crop (kg/ha)	2013 Total Standing Crop (kg/ha)	2014 Total Standing Crop (kg/ha)	2015 Total Standing Crop (kg/ha)	Percent Change Between 2014 and 2015
Rush Creek – Upper	178	140	167	123	-26%
Rush Creek - Bottomlands	103	55	52	59	+13%
Walker Creek	156	194	189	183	-3%

Table 13. Comparison of total (brown and rainbow trout) standing crop (kg/ha) estimates between 2012, 2013, 2014 and 2015 for the Lee Vining Creek sections.

Collection Location	2012 Total Standing Crop (kg/ha)	2013 Total Standing Crop (kg/ha)	2014 Total Standing Crop (kg/ha)	2015 Total Standing Crop (kg/ha)	Percent Change Between 2014 and 2015
Lee Vining Creek - Main Channel	173	184	140	150	+7%
Lee Vining Creek - Side Channel	39	26	30	45	+50%
Lee Vining Creek – Main and Side Channel Combined	143	165	126	145	+15%

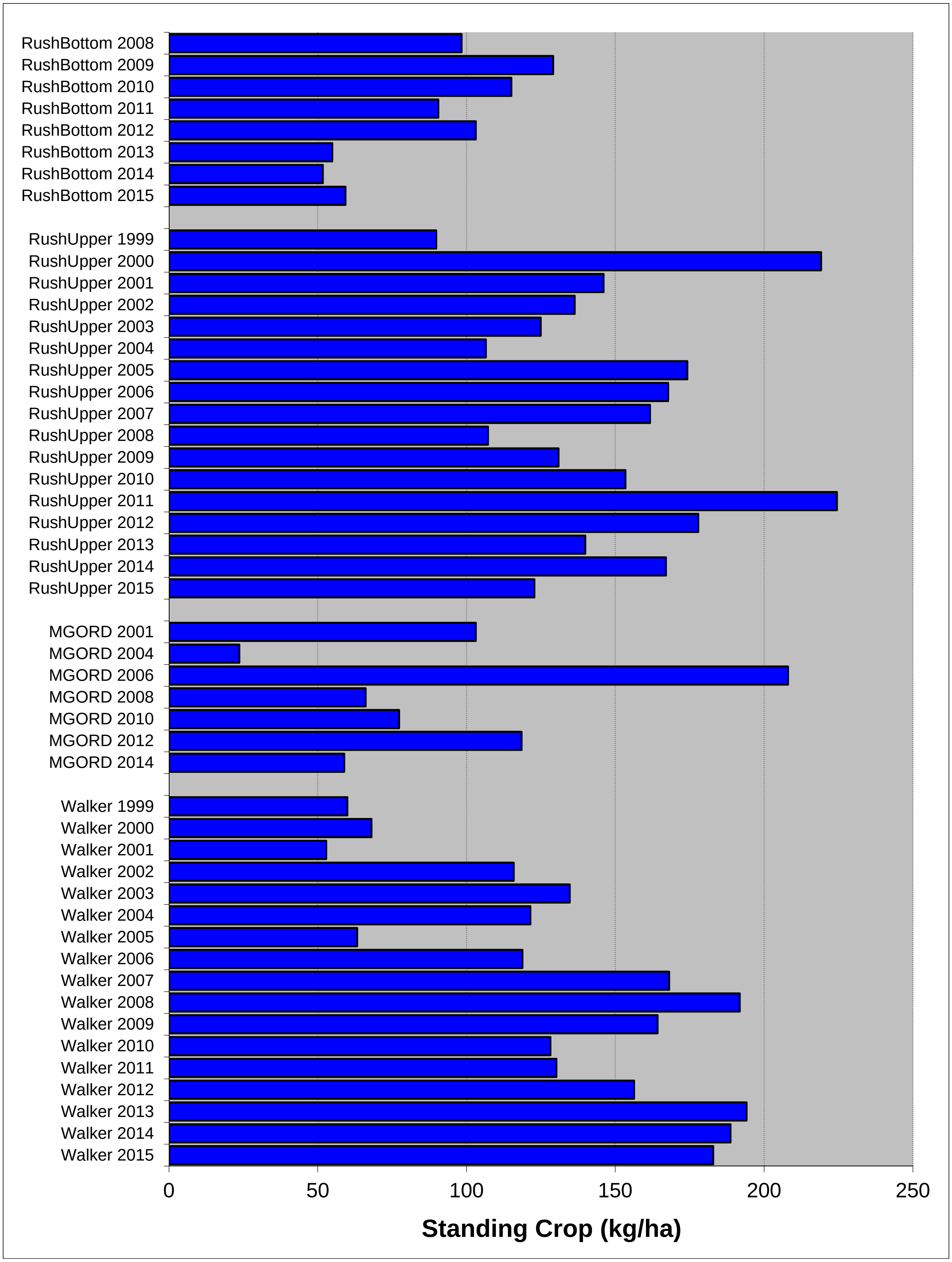

Figure 22. Estimated total standing crop (kilograms per hectare) of brown trout in Rush Creek sample sections from 1999 to 2015. NOTE: After 2001, MGORD estimates only made during even years.

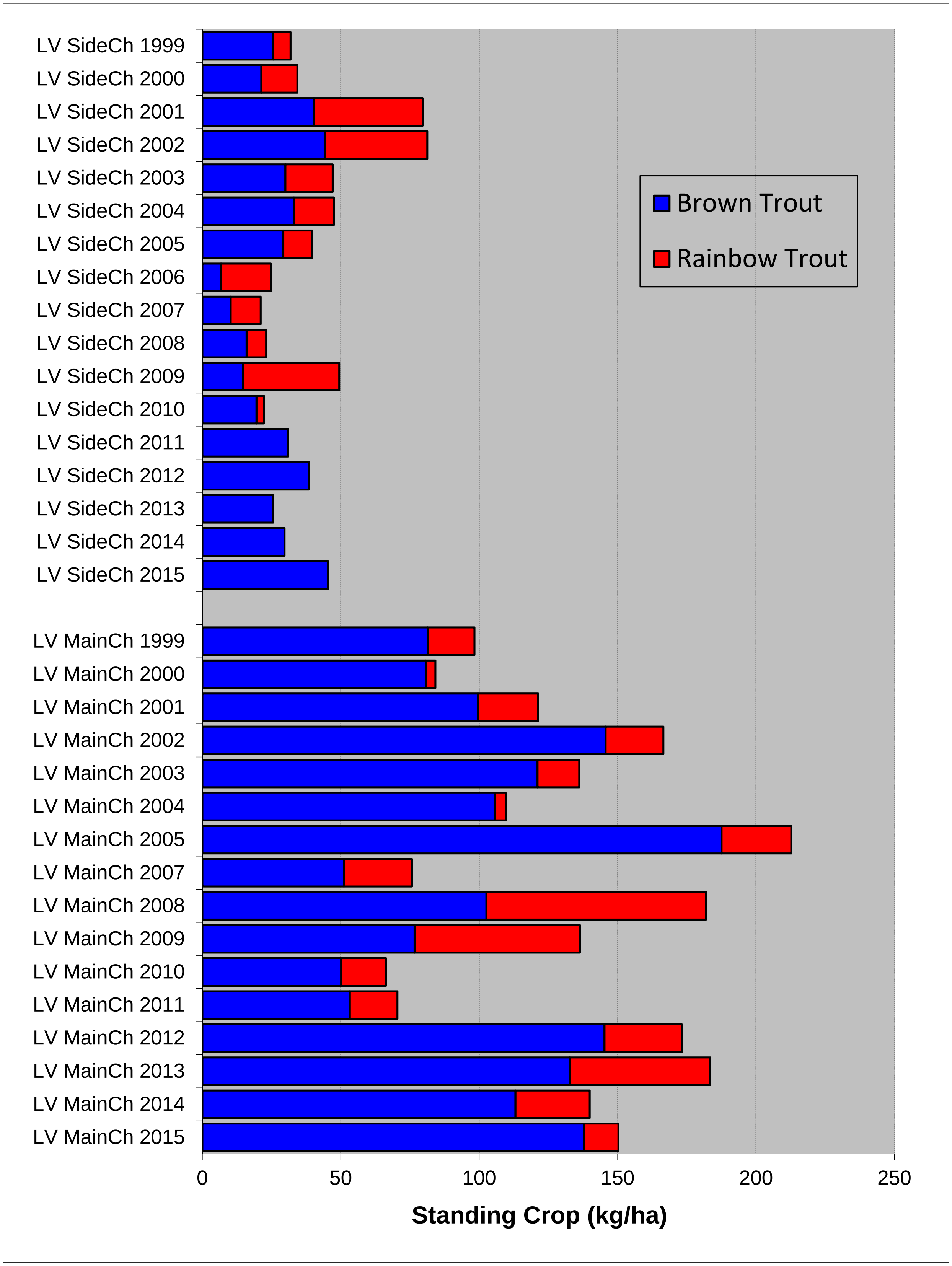

Figure 23. Estimated total standing crop (kilograms per hectare) of brown trout and rainbow trout (red) in Lee Vining Creek sample sections from 1999 to 2015.

Relative Stock Density (RSD) Results for Rush and Lee Vining Creeks

In the Upper Rush section, the 2015 RSD-225 value of 15 was the first increase after four consecutive years of declining RSD-225 values (Table 14). The number brown trout ≥225 mm (16 fish) was the sixth lowest total for this size class in the 15 sampling years. The RSD-300 value was 1 in 2015, which has not changed for the past five sampling years (Table 14). Over the 16 sampling years, a total of 89 brown trout ≥300 mm were captured in the Upper Rush Creek section, an average of 5.6 fish ≥300 mm per year (Table 14).

In the Bottomlands section of Rush Creek, since the 2010 value of 27, the RSD-225 steadily dropped for four years to a value of 1 in 2014 (Table 14). In 2014, only two brown trout ≥225 mm were captured in the Bottomlands section and one of these was a large PIT-tagged fish that had moved downstream from the MGORD. In 2015, the RSD-225 value increased to a value of 23, the second highest value for the eight sampling years (Table 14). In 2015, 27 brown trout ≥225 mm in length were captured (Table 14). The average number of brown trout ≥225 mm captured over the eight-year sampling history was 34 trout per year, with only six fish ≥225 mm captured in 2013 and 2014 (Table 14). The RSD-300 value was 1 in 2015, based on the capture of a single brown trout ≥300 mm (Table 14). Over the eight sampling years, a total of nine brown trout ≥300 mm were captured in the Bottomlands section, an average of 1.1 fish ≥300 mm per year (Table 14).

In the MGORD, the RSD-225 value increased from 53 in 2014 to 72 in 2015 (Table 14). In 2015, the RSD-300 value was 25, a more than three-fold increase from a value of 7 in 2014, which was the lowest ever recorded for the 14-year period (Table 14). The RSD-375 value in 2015 was 8, up from a value of 3 in 2014, which was the lowest value since 2008 (Table 14). The increased RSD-300 and RSD-375 values in 2015 were solely a function of the low numbers of trout ≥150 mm captured and do not reflect that more, larger fish were present in the MGORD. In fact, equal numbers of brown trout ≥300 mm (29 fish) were captured during the 2014 and 2015 sampling seasons (Table 14). For sampling conducted between 2001 and 2012, the annual average catch of trout ≥300 mm equaled 180 fish/year; then for the past three sampling years the annual average catch of trout ≥300 mm equaled 38 fish/year (Table 14). This 79% decline in larger brown trout coincided with the three years of low flows and poor thermal regimes within the MGORD.

RSD values in Lee Vining Creek were generated for the main channel combined with the side channel and for the main channel only (Table 15). Slightly greater numbers of trout ≥150 mm were captured in 2015, compared to 2014 (Table 15). However, fewer trout ≥225 mm were captured in 2015 resulted in decreased RSD-225 values for the main/side combined and main-only (9 in both sections) when compared to 2014's values (Table 15). For a second straight year, no trout greater than 300 mm in length were captured in Lee Vining Creek (Table 15).

Table 14. RSD values for brown trout in Rush Creek sections from 2000 to 2015.

Sampling Location Rush Creek	Sample Year	Number of Trout ≥150 mm	Number of Trout ≥150-224 mm	Number of Trout 225-299 mm	Number of Trout 300-374 mm	Number of Trout ≥375 mm	RSD-225	RSD-300	RSD-375
Upper Rush	**2015**	**289**	**246**	**41**	**0**	**2**	**15**	**1**	**1**
Upper Rush	2014	366	331	31	4	0	10	1	
Upper Rush	2013	336	288	45	3	0	14	1	
Upper Rush	2012	354	284	66	3	1	20	1	
Upper Rush	2011	498	381	110	6	1	23	1	
Upper Rush	2010	308	202	97	7	2	34	3	1
Upper Rush	2009	372	322	43	5	2	13	2	1
Upper Rush	2008	227	189	31	6	1	17	3	
Upper Rush	2007	282	210	61	9	2	26	4	1
Upper Rush	2006	233	154	69	10	0	34	4	
Upper Rush	2005	202	139	56	5	2	31	3	
Upper Rush	2004	179	112	64	2	1	37	2	
Upper Rush	2003	264	216	45	2	1	18	1	
Upper Rush	2002	220	181	35	1	2	18	2	1
Upper Rush	2001	223	190	27	6	0	15	3	
Upper Rush	2000	182	158	22	2	0	13	1	
Bottomlands	**2015**	**115**	**88**	**26**	**0**	**1**	**23**	**1**	**1**
Bottomlands	2014	154	152	1	0	1	1	1	1
Bottomlands	2013	128	123	5	0	0	4	0	
Bottomlands	2012	325	290	34	1	0	11	0	
Bottomlands	2011	267	218	46	3	0	18	1	
Bottomlands	2010	307	225	81	1	0	27	0	
Bottomlands	2009	379	321	56	1	1	15	1	
Bottomlands	2008	160	141	19	0	0	12	0	
MGORD	**2015**	**116**	**33**	**54**	**20**	**9**	**72**	**25**	**8**
MGORD	2014	388	184	175	19	10	53	7	3
MGORD	2013	411	237	118	41	15	42	14	4
MGORD	2012	694	176	319	173	26	75	29	4
MGORD	2011	216	36	117	55	8	83	29	4
MGORD	2010	694	252	292	115	35	64	22	5
MGORD	2009	643	156	338	123	26	76	23	4
MGORD	2008	856	415	301	118	22	52	16	3
MGORD	2007	621	144	191	259	27	77	46	4
MGORD	2006	567	60	200	280	27	89	54	5
MGORD	2004	424	130	197	64	33	69	23	8
MGORD	2001	774	330	217	119	108	57	29	14

Table 15. RSD values for brown and rainbow trout in the Lee Vining Creek main channel and side channel sections from 2008 to 2015. RSD values for brown and rainbow trout in the Lee Vining Creek main channel section from 2000 to 2015.

Sampling Location Rush Creek	Sample Year	Number of Trout ≥150 mm	Number of Trout ≥150-224 mm	Number of Trout 225-299 mm	Number of Trout 300-374 mm	Number of Trout ≥375 mm	RSD-225	RSD-300
Main & Side	**2015**	**227**	**206**	**21**	**0**	**0**	**9**	**0**
Main & Side	2014	212	184	28	0	0	13	0
Main & Side	2013	327	309	17	1	0	6	0
Main & Side	2012	128	87	39	2	0	32	2
Main & Side	2011	78	46	26	5	1	41	1
Main & Side	2010	68	31	35	2	0	54	3
Main & Side	2009	192	159	32	1	0	17	1
Main & Side	2008	252	242	19	0	0	8	0
Main Channel	**2015**	**210**	**192**	**18**	**0**	**0**	**9**	**0**
Main Channel	2014	200	173	27	0	0	14	0
Main Channel	2013	325	308	16	1	0	5	0
Main Channel	2012	111	72	37	2	0	35	2
Main Channel	2011	60	31	23	5	1	48	10
Main Channel	2010	62	28	32	2	0	55	3
Main Channel	2009	137	106	30	1	0	23	1
Main Channel	2008	149	138	11	0	0	7	0
Main Channel	2007	29	24	5	0	0	17	0
Main Channel	2006*	NS	NS	NS	NS	NS	-	-
Main Channel	2005	60	37	20	2	1	38	5
Main Channel	2004	70	60	8	2	0	14	3
Main Channel	2003	52	27	23	2	0	48	4
Main Channel	2002	100	74	23	3	0	26	3
Main Channel	2001	90	71	16	3	0	21	3
Main Channel	2000	51	32	18	1	0	37	2

*not sampled due to high flows.

Termination Criteria Results

The Rush Creek sampling sections for years 2011 through 2015, failed to meet four of the five termination criteria for any of the three, three-year running averages.

The Upper Rush section met the density criterion for all three of the three-year running averages. For the most recent three-year running average (2013-2015) density was the only criteria met (Table 16).

Table 16. Termination criteria analyses for the Upper Rush section of Rush Creek. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	2013 – 2015 Average	2012 – 2014 Average	2011 – 2013 Average
Biomass (≥175 kg/ha)	143	162	**181**
Density (≥3,000 trout/km)	**4,382**	**6,322**	**8,408**
Condition Factor (≥1.00)	0.98	0.98	0.98
RSD-225 (≥35)	13	15	19
RSD-300 (≥5)	1	1	1
Conclusion	**Met one of five TC**	**Met one of five TC**	**Met two of five TC**

For the 2013-2015 three-year average, the Bottomlands section failed to meet any of the termination criteria (Table 17).

Table 17. Termination criteria analyses for the Bottomlands of Rush Creek. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	2013 – 2015 Average	2012 – 2014 Average	2011 – 2013 Average
Biomass (≥175 kg/ha)	55	70	83
Density (≥3,000 trout/km)	1,500	2,095	2,640
Condition Factor (≥1.00)	0.94	0.93	0.92
RSD-225 (≥35)	9	5	11
RSD-300 (≥5)	1	0	0
Conclusion	**Met none of five TC**	**Met none of five TC**	**Met none of five TC**

For the 2013-2015 three-year average, the MGORD met the RSD-375 termination criterion of ≥5 (Table 18).

Table 18. Termination criteria analyses for the MGORD section of Rush Creek. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	**2013 – 2015 Average**	**2012 – 2014 Average**	**2011 – 2013 Average**
RSD-225 (≥60)	56	57	**67**
RSD-300 (≥30)	15	17	24
RSD-375 (≥5)	**5**	3	4
Conclusion	**Met TC one of three RSD values**	**Met TC none of three RSD values**	**Met TC one of three RSD values**

For the 2013-2015 three-year average, the main and side channel of Lee Vining Creek together met the density criterion only (Table 19).

Table 19. Termination criteria analyses for the Lee Vining Creek sample sections. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	**2013 - 2015 Average**	**2012 - 2014 Average**	**2011 - 2013 Average**
Biomass (≥150 kg/ha)	145	145	123
Density (≥1,400 trout/km)	**1,947**	**2,306**	**1,902**
Condition Factor (≥1.00)	0.94	0.95	**1.01**
RSD-225 (≥30)	9	17	26
Conclusion	**Met one of four TC**	**Met one of four TC**	**Met two of four TC**

PIT Tag Recaptures

PIT Tags Implanted between 2009 and 2015

In 2009, a total of 1,596 trout received PIT tags and adipose fin clips in Rush, Lee Vining, and Walker Creeks (Table 20). Of the 1,596 trout tagged, 711 were age-0 and 861 were age-1+ brown trout, 19 were age-0 rainbow trout, and five were age-1 and older rainbow trout. In 2008, age-0 trout received adipose fin clips to help track growth rates of that cohort of trout into the future. Knowing that this cohort of trout was age-1 in 2009, 224 trout with adipose fin clips were PIT tagged in 2009. All trout in the MGORD were tagged; a total of 54 age-0 brown trout and 642 age-1 and older brown trout. No rainbow trout were captured in the MGORD. Most of these trout in the MGORD were older than age-1.

In 2010, a total of 1,274 trout received PIT tags and adipose fin clips in Rush, Lee Vining, and Walker Creeks (Table 21). Of the 1,274 trout, 855 were age-0 and 43 were age-1 and older brown trout. Four age-0 and one age-1 and older rainbow trout received PIT tags and adipose fin clips. Again all trout in the MGORD (371 trout) were tagged and given an adipose fin clip. Of the 371 trout, 359 were age-1 and older brown trout and 12 were age-1 rainbow trout. Like 2009, most of the trout tagged in the MGORD were older than age-1.

In 2011, a total of 1,065 trout received adipose fin clips and PIT tags in Rush, Lee Vining, and Walker Creeks (Table 22). Of these 1,065 trout, 851 were age-0 brown trout and 19 were age-1 and older brown trout. Fifty age-0 rainbow trout received PIT tags and adipose fin clips. All age-1 and older trout in the MGORD (145 trout) were tagged and given adipose fin clips. Of the 145 trout 142 were age-1 and older (mostly older) brown trout and three were age-1 and older rainbow trout.

In 2012, a total of 496 trout received PIT tags and adipose fin clips in Rush, Lee Vining, and Walker Creeks (Table 23). Of the 496 trout tagged, 412 were age-0 and 4 were age-1 and older brown trout. For rainbow trout, only age-0 fish were tagged in 2012 which totaled 80 trout. No new tags were implanted in trout in the County Road section, but trout with missing adipose fins and did not produce a tag number when scanned were retagged. No trout in the MGORD in 2012 were tagged or retagged due to a limited number of PIT tags available for deployment.

In 2013, no PIT tags were implanted in any fish. Only length and weight data from recaptures of previously tagged fish were collected during the September 2013 sampling.

In 2014, a total of 964 trout received PIT tags and adipose fin clips in Rush, Lee Vining, and Walker Creeks (Table 24). Of the 964 trout tagged, 459 were age-0 and 477 were age-1 and older brown trout. For rainbow trout, six age-0 fish were tagged and 22 age-1 and older fish were tagged. Because no PIT tags were deployed in 2013, suspected age-1 trout were tagged in 2014 and these fish were between 125 mm and 170 mm in length.

Table 20. Total numbers of trout implanted with PIT tags during the 2009 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout	Number of Age-1 Brown Trout	Number of Age-0 Rainbow Trout	Number of Age-1 Rainbow Trout	Reach Totals
Rush Creek	Upper Rush	256	26	15	1	**298 Trout**
	Bottomlands	164	68	0	0	**232 Trout**
	County Road	108	29	0	0	**137 Trout**
	MGORD	54	642*	0	0	**696 Trout**
Lee Vining Creek	Main Channel	10	45	4	3	**62 Trout**
	Side Channel	5	0	0	1	**6 Trout**
Walker Creek	Above old 395	114	51	0	0	**165 Trout**
Totals:		**711**	**861**	**19**	**5**	**Total Trout: 1,596**

*Many of these MGORD trout were >age-1.

Table 21. Total numbers of trout implanted with PIT tags during the 2010 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 and older Brown Trout	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 and older Rainbow Trout	Reach Totals
Rush Creek	Upper Rush	242	11	4	0	**257 Trout**
	Bottomlands	284	3	0	0	**287 Trout**
	County Road	210	7	0	0	**217 Trout**
	MGORD	1	359*	0	12	**372 Trout**
Lee Vining Creek	Main Channel	24	8	0	1	**33 Trout**
	Side Channel	13	0	0	0	**13 Trout**
Walker Creek	Above old 395	81	14	0	0	**95 Trout**
Totals:		**855**	**402**	**4**	**13**	**Total Trout: 1,274**

*Many of these MGORD trout were >age-1.

Table 22. Total numbers of trout implanted with PIT tags during the 2011 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 and older Brown Trout	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 and older Rainbow Trout	Reach Totals
Rush Creek	Upper Rush	393	3	30	0	**426 Trout**
	Bottomlands	178	1	11	0	**190 Trout**
	County Road	196	1	6	0	**203 Trout**
	MGORD	8	142*	3	3	**156 Trout**
Lee Vining Creek	Main Channel	24	0	0	0	**24 Trout**
	Side Channel	11	14	0	0	**25 Trout**
Walker Creek	Above old 395	41	0	0	0	**41 Trout**
Totals:		**851**	**161**	**50**	**3**	**Total Trout: 1,065**

*Many of these MGORD trout were >age-1.

Table 23. Total numbers of trout implanted with PIT tags during the 2012 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 and older Brown Trout	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 and older Rainbow Trout	Reach Totals
Rush Creek	Upper Rush	117	1	2	0	**120 Trout**
	Bottomlands	110	1	6	0	**117 Trout**
	County Road	0	2	0	0	**2 Trout**
	MGORD	0	0	0	0	**0 Trout**
Lee Vining Creek	Main Channel	125	0	72	0	**197 Trout**
	Side Channel	0	0	0	0	**0 Trout**
Walker Creek	Above old 395	60	0	0	0	**60 Trout**
Age Class Sub-totals:		**412**	**4**	**80**	**0**	**Total Trout: 496**

Table 24. Total numbers of trout implanted with PIT tags during the 2014 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 Brown Trout (125-170 mm)	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 Rainbow Trout (125-170 mm)	Section Totals
Rush Creek	Upper Rush	243	86	1	0	**330 Trout**
	Bottomlands	34	43	0	0	**77 Trout**
	MGORD	13	125-199 mm = 60 brown trout ≥200 mm = 185 brown trout			**258 Trout**
Lee Vining Creek	Main Channel	127	103	5	22	**257 Trout**
	Side Channel	0	0	0	0	**0 Trout**
Walker Creek	Above old 395	42	0	0	0	**42 Trout**
Age Class Sub-totals:		**459**	**232***	**6**	**22**	**Total Trout: 964**

*this sub-total excludes age-1 and older MGORD fish

In 2015, a total of 863 trout received PIT tags and adipose fin clips in Rush, Lee Vining, and Walker Creeks (Table 25). In addition, eight recaptured adipose fin-clipped fish had shed their original tags and were re-tagged, thus a total of 871 PIT tags were deployed during the 2015 fisheries sampling (Table 25). Of the 871 trout tagged, 738 were age-0 brown trout and 126 were age-1 and older brown trout (Table 25). For rainbow trout, seven age-0 fish were tagged in the Upper Rush section (Table 25).

Table 25. Total numbers of trout implanted with PIT tags during the 2015 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 and older Brown Trout	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 and older Rainbow Trout	Section Totals
Rush Creek	Upper Rush	234	2*	7	0	**243 Trout**
	Bottomlands	167	3*	0	0	**170 Trout**
	MGORD	29	125-199 mm = 37 brown trout ≥200 mm = 83 brown trout (2 shed/new)			**149 Trout**
Lee Vining Creek	Main Channel	195	1*	0	0	**196 Trout**
	Side Channel	0	0	0	0	**0 Trout**
Walker Creek	Above old 395	113	0	0	0	**113 Trout**
Age Class Sub-totals:		**738**	**6****	**7**	**0**	**Total Trout: 871**

*shed tag/new tag implanted
**this sub-total excludes age-1 and older MGORD fish

In September of 2015, a total of 87 previously tagged trout were recaptured in Rush Creek (Appendix B: Table 1). Most of the recaptures occurred in the Upper section of Rush Creek (36 fish), followed by 20 recaptures in Walker Creek, 18 recaptures in the Bottomlands section of Rush Creek, and 13 recaptures in the MGORD (Appendix B: Table 1). Most fish were recaptured in the sections where they were initially captured and PIT-tagged, except for four brown trout initially tagged in Upper Rush Creek. Three of these fish were recaptured in the MGORD and one fish was recaptured in the Bottomlands section (Appendix B: Table 1). In September of 2015, a total of 74 previously tagged trout were recaptured in Lee Vining Creek; 68 brown trout and six rainbow trout (Appendix B: Table 2).

In the following text, growth between 2014 and 2015 will be referred as 2015 growth rates. A 2015 trout refers to a fish recaptured in September of 2015. An age of a PIT tagged trout reflects the age during the sampling year. For instance, an age-1 trout in 2015 indicates that a trout had been tagged in 2014 as age-0 and its length and weight were measured in 2015 when it was recaptured.

Growth of Age-1 Brown Trout between 2014 and 2015

In 2015, a total of 96 known age-1 brown trout were recaptured that were tagged as age-0 fish in 2014, for a recapture rate of 20.9% (96/459 age-0 fish tagged in 2014). Of the 96 age-1 recaptures; 53 of these fish were from Rush Creek sections and 37 fish were from the Lee Vining Creek main channel section.

In the Bottomlands section of Rush Creek, six age-1 brown trout were recaptured in 2015 and the average growth rates of these trout were 84 mm and 41 g (Table 26). Compared to 2013 rates (no data available for 2014), the growth rate of the six age-1 brown trout was greater by 28 mm and 17 g (Table 26). Growth rates of age-1 brown trout in the Bottomlands section had generally declined annually from 2010 to 2014, but the 2015 growth rates were the greatest since 2009 (Table 26).

In the Upper section of Rush Creek, 31 age-1 brown trout were recaptured in 2015 and the average growth rates of these trout were 90 mm and 55 g (Table 26). Compared to 2013 rates (no data available for 2014), the average growth rates of the 31 age-1 brown trout were greater by 23 mm and 20 g (Table 26). Growth rates of age-1 brown trout in the Upper Rush section had generally declined annually from 2010 to 2014, but the 2015 growth rates were the greatest since 2009 (Table 26).

In Walker Creek, 16 age-1 brown trout were recaptured in 2015 and the average growth rates of these trout were 58 mm and 24 g (Table 26). Compared to 2013 rates (no data available for 2014), the average growth rates of the 16 age-1 brown trout in 2015 were similar (-1 mm in length and 1+ g in weight) (Table 26).

In Lee Vining Creek, 37 age-1 brown trout were recaptured in 2015 and the average growth rates of these trout were 73 mm and 33 g (Table 26). Compared to 2013 rates (no data available for 2014), the average growth rates of the 37 age-1 brown trout were greater by 12 mm and 6 g

(Table 26). Growth rates of age-1 brown trout in Lee Vining Creek for the five years of available data have averaged 77 mm in length and 38 g in weight (Table 26).

Growth of Age-2 Brown Trout between 2014 and 2015

In 2015, a total of 41 known age-2 brown trout were recaptured that were tagged as age-1 fish in 2014 (no tags were deployed in 2013), for a recapture rate of 17.6% (41/232 age-1 fish tagged in 2014). Of these 41 fish, 16 were recaptured in Rush Creek and 25 were recaptured in Lee Vining Creek.

In the Bottomlands section of Rush Creek, six age-2 fish was recaptured in 2015 and had average growth rates of 62 mm and 62 grams (Table 26). Compared to 2014 rates, the growth rates of the six 2015 age-2 brown trout were greater by 30 mm and 33 g (Table 26). The 2015 growth rates of age-2 brown trout in the Bottomlands section were the highest recorded for the six years of available data (Table 26). Growth rates of age-2 brown trout in the Bottomlands for these six years have averaged 39 mm in length and 38 g in weight (Table 26).

In the Upper section of Rush Creek, ten age-2 fish was recaptured in 2015 and had average growth rates of 64 mm and 69 grams (Table 26). Compared to 2013 rates, the growth rate of the ten 2015 age-2 brown trout was greater by 23 mm and 27 g (Table 26). Growth rates of age-2 brown trout in the Upper Rush sampling section for the five years of available data have averaged 52 mm in length and 59 g in weight (Table 26).

The Lee Vining Creek main channel had 25 age-2 PIT tagged brown trout recaptured in 2015. The average growth rates of these trout were 47 mm and 40 g (Table 26). When compared to the 2014 growth rates of age-2 fish, the 2015 growth rates increased by 34% for length and increased by 38% for weight (Table 26). Growth rates of age-2 brown trout in the Lee Vining Creek main channel section have averaged 52 mm in length and 62 g in weight for the five years of available data (Table 26).

In Walker Creek no age-2 PIT tagged brown trout recaptured in 2015 because no age-1 fish were tagged in 2014 and no age-0 fish were tagged in 2013 (Table 26).

Growth of Age-3 Brown Trout between 2014 and 2015

In 2015, a total of six known age-3 brown trout were recaptured that were tagged as age-0 fish in 2012, for a recapture rate of 0.9% (8/851 age-0 fish tagged in 2011). The one-year growth of trout between age-2 and age-3 was typically less than the one-year growth rates of younger fish.

In the Upper Rush section, no PIT tagged age-3 brown trout were recaptured during the 2015 sampling that had also been recaptured as age-2 fish in 2014.

In the Bottomlands section, no PIT tagged age-3 brown trout were recaptured during the 2015 sampling that had also been recaptured as age-2 fish in 2014.

In the Lee Vining Creek main channel, three PIT tagged age-3 brown trout was recaptured in 2015 and these three fish have been recaptured each year since being tagged at age-0 in 2012. These three trout had average growth rates of 27 mm and 32 g (Table 26). Known age-3 brown trout have now been recaptured in Lee Vining Creek for three consecutive years (Table 26). In 2015, three additional PIT-tagged age-3 brown trout were captured in Lee Vining Creek, yet these fish were not recaptured at age-2 in 2014, thus no 2014-15 growths were calculated.

In Walker Creek, three PIT tagged age-3 brown trout were recaptured in 2015 and these three fish have been recaptured each year since being tagged at age-0 in 2012. These three trout had average growth rates of 27 mm and 29 g. Compared to 2014 rates, the growth rates of age-3 brown trout increased by 35% for length and decreased by 19% for weight in 2015 (Table 26).

Growth of Age-4 and Age-5 Brown Trout between 2014 and 2015

In Walker Creek, a single age-4 brown trout was recaptured in 2015 and this fish has been recaptured every year since it was tagged at age-0 in 2011. Between 2014 and 2015, this fish gained 28 mm in length and 45 g in weight (Table 26).

No known age-5 PIT tagged brown trout were captured in Rush or Lee Vining creeks during the September 2015 sampling.

Growth of Age-1 Rainbow Trout in Lee Vining Creek between 2014 and 2015

In 2015, a total of two known age-1 rainbow trout were recaptured in Lee Vining Creek that were tagged as age-0 fish in 2014, for a recapture rate of 40% (2/5 age-0 fish tagged in 2014). Average growth rates of these two fish were 80 mm and 35 g (Table 26). Previously, 2013 was the only year that age-1 rainbow trout with PIT tags were recaptured, and these growth rates averaged 78 mm in length and 47 g in weight (Table 26).

Growth of Age-2 Rainbow Trout in Lee Vining Creek between 2014 and 2015

In 2015, four known age-2 rainbow trout were recaptured in Lee Vining Creek that were tagged as age-1 fish in 2014, for a recapture rate of 18.2% (4/22 age-1 fish tagged in 2014). Average growth rates of these four fish were 52 mm and 50 g (Table 26). Previously only one age-2 rainbow trout with PIT tags was recaptured in 2014 and this fish experienced growth rates of 40 mm in length and 48 g in weight (Table 26).

Table 26. Average growth (length and weight) of all brown trout recaptured from 2009 through 2015 by age. Note: *denotes only one fish recaptured.

Stream and Reach	Cohort	Average Annual Growth Length (mm)							Average Annual Growth Weight (g)						
		2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Upper Rush Creek	Age 1	89	81	83	72	67		90	51	50	48	33	35		55
	Age 2		58	54	43	41		64		70	73	42	42		69
	Age 3				14		24					29		41	
	Age 4					12							-22		
	Age-5														
Rush Creek Bottom-lands	Age 1	84	77	71	58	56		84	43	40	35	25	24		41
	Age 2		50	35	30	27	32*	62		54	32	28	22	29*	62
	Age 3			13	17	11	35				14	16	9	31	
	Age 4				4		18					-11		20	
	Age-5														
Lee Vining Main Channel	Age 1		80*	72	99	61		73		42*	37	52	27		33
	Age 2		66		77	33	35	47		95		110	34	29	40
	Age 3			34		23*	16*	27			92		48*	20*	32
	Age 4				21*							41*			
	Age-5														
LV Main Channel Rainbow Trout	Age 1					78		80					47		35
	Age 2						40*	52						48*	50
	Age 3														
	Age 4														
	Age-5														
Walker Creek Above Old 395	Age 1	68	51	71	68	59		58	27	20	34	36	23		24
	Age 2		31	60	40	27	39			26	56	33	21	35	
	Age 3			28	18	9	20	27			44	12	2	36	29
	Age 4				7	2*		28*				2	-16*		45*
	Age-5						0*							-10*	

Growth of MGORD Brown Trout by size class between 2014 and 2015

Because the actual age at-time-of-tagging was unknown for most trout PIT tagged in the MGORD, determination of actual ages of recaptured trout was not possible. Thus, growth rate comparisons within the MGORD were based on size classes (Table 27). Due to the majority of the brown trout in the MGORD being larger sized, size classes were based on the RSD values for the MGORD. When evaluating growth rates by size classes, the size classes in Table 28 designate each fish's size class in 2014, not its size class at the time of recapture in 2015.

In 2015, a total of 10 PIT tagged brown trout were recaptured in the MGORD that were originally PIT tagged in the MGORD. Of these 10 recaptures, eight fish had also been captured in 2014, thus one-year growth rates between 2014 and 2015 were calculated for these fish (Table 27).

No PIT tagged brown trout captured in the MGORD in 2014 within the <125 mm size class were recaptured in 2015.

There was one PIT tagged brown trout captured in the MGORD in 2014 within the 125-225 mm size class (222 mm) that was recaptured in 2015. This trout grew 70 mm in length and gained 155 g in weight (Table 27).

There were four PIT tagged brown trout captured in the MGORD in 2014 within the 226-300 mm size class that were recaptured in 2015. These four trout had average growth rates of 61 mm and 203 g between 2014 and 2015 (Table 27). All four fish experienced weight gains, ranging from 162 g to 229 g.

There was one PIT tagged brown trout captured in the MGORD in 2014 within the 301-375 mm size class (307 mm) that was recaptured in 2015. This trout grew 84 mm in length and gained 421 g in weight (Table 27).

There were two PIT tagged brown trout captured in the MGORD in 2014 within the >375 mm size class (398 and 410 mm) that were recaptured in 2015. These two trout had average growth rates of 69 mm and 718 g between 2014 and 2015 (Table 27). Both fish experienced large weight gains, 692 g and 743 g.

Table 27. Average growth rates, length (mm) and weight (g), of all MGORD brown trout recaptured from 2009 through 2015 by size class. Note: *denotes only one fish recaptured.

Size Class (mm)	Average Annual Growth Length (mm)					
	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
0-124	121					
125-225	55	59	63			70*
226-300	32	39	22	7		61
301-375	20	17	9	12	30*	84*
>375	13	18	-1	10	17	69
Size Class (mm	**Average Annual Growth Weight (g)**					
	2009-2010	**2010-2011**	**2011-2012**	**2012-2013**	**2013-2014**	**2014-2015**
0-124	91					
125-225	85	90	78			155*
226-300	53	81	34	2		203
301-375	23	54	-5	49	178*	421*
>375	-10	134	-47	-2	283	718

Growth of MGORD Brown Trout from non-consecutive years

Two of the 10 PIT tagged brown trout captured in the MGORD during the September 2015 sampling were last recaptured, measured and weighed in years prior to 2014; thus annual growth calculations were not possible. These two brown trout exhibited variable growth patterns (Table 28). The brown trout with PIT tag #7031639 was tagged in 2009, recaptured in 2013, and had lost weight during this four-year period (Table 28). Then in the following two years (2013 to 2015), this fish gained 334 g in weight. When recaptured in 2015, this fish had carried its PIT tag for six years and was at least an eight year old fish.

The other non-consecutive recapture in September 2015 was of a brown trout initially tagged in 2011 (#1871652) that recaptured for the first time in 2015. During this four year period between captures, this fish grew 54 mm in length and gained 942 g (Table 28).

Table 28. PIT tagged brown trout caught in the MGORD section, nonconsecutive recaptures.

Last 7 Digits of PIT Tag #	Year of Capture	Total Length (mm)	Weight (g)	Difference in Length (mm)	Difference in Weight (g)
#7031639	2009	383	594		
	2013	397	460	+14	-134
	2015	423	794	+26	+334
#1871652	2011	341	392		
	2015	495	1,334	+54	+942

Movement of PIT Tagged Trout between Sections

From 2009 to 2015 a total of 6,063 PIT tags were surgically implanted in brown and rainbow trout in the following stream reaches: Upper Rush, County Road, Bottomlands, MGORD, and Walker Creek. Between 2010 and 2015, 31 brown trout have been recaptured in a stream reach other than where they were initially tagged. The majority of movement between sections has occurred from the Upper Rush section upstream into the MGORD, and from the MGORD downstream into the Upper Rush section. We also documented some limited movement between the Bottomlands and County Road sections. Up to 2013, no movement between other sections had been recorded. However in 2014, a large brown trout initially tagged in the MGORD was recaptured in the Bottomlands section.

The 2012 Annual Fisheries Report presented the summarized data for 23 brown trout that had moved from one section to another. In all cases, fish which moved experienced higher growth rates than other members of their cohorts which stayed in the section where they had been tagged (LADWP 2013). These growth differences were most markedly different for brown trout PIT tagged as age-0 fish in the Upper Rush section that were eventually recaptured in the MGORD as age-1 or age-2 fish. Since the 2012 report, this phenomenon of superior growth rates by fish that moved relatively large distances has continued. For example, three brown trout tagged as age-0 fish in Upper Rush in 2014 where recaptured in 2015 in different sampling sections; two were recaptured in the MGORD and one was recaptured in the Bottomlands. These three fish experienced average growth rates of 100 mm in length and 79 g in weight; compared to average growth rates of 88 mm and 53 g for the age-1 fish that remained in the Upper Rush section.

PIT Tag Shed Rate of Trout Recaptured in 2015

In 2015, a total of 169 trout with adipose fin clips were recaptured and eight of these fish failed to produce a PIT tag number when scanned with the tag reader. Assuming that all these fish were previously PIT tagged, the 2015 calculated shed rate was 4.7% (8 shed tags/169 clipped fish recaptured). This rate was slightly greater than rates reported by other PIT tagging studies for juvenile trout: 3% for juvenile brown trout (Ombredane et al. 1998) and 3% for juvenile steelhead (Bateman and Gresswell 2006). Our relatively low shed rate may also be attributed to only tagging age-0 fish ≥70 mm in length because some research has documented increasing shed rates for smaller sized brown trout. For example, one study calculated 10.6% and 30.6% shed rates for brown trout 50-55 mm in length (injection versus surgical implantation) and 13.4% shed rate for brown trout 56-60 mm in length (Richard et al. 2013).

Interestingly, research of long-term PIT tag retention in trout of spawning age has documented significantly higher shed rates; such as shed rates of 25% or greater (Bateman et al. 2009). This study documented that tags were shed by both female and male coastal cutthroat trout during spawning and that some individual fish were retagged up to three times during their four-year study period (Bateman et al. 2009). The lengths of the eight brown trout we recaptured in 2015 that had shed their PIT tags suggest that at least 50% of the fish were ≥age-2 and of spawning age. These lengths were as follows: in the MGORD = 371 and 454 mm; in Upper Rush = 169 and 201 mm; in Bottomlands = 224, 225, and 278 mm; and in Lee Vining Creek = 178 mm.

Comparison of Length-at Age amongst Sample Sections

During 2015, four age-classes of PIT tagged brown trout were recaptured within four fisheries monitoring sections in Rush, Walker and Lee Vining creeks (Table 29). Along with providing age-specific length information for each section, these data also allowed comparisons of length-at-age between sample sections and also between the years 2013, 2014 and 2015 (Table 29). Unfortunately, the limited number of PIT tags deployed in 2012 and the absence of a tagging program in 2013 reduced opportunities to generate comparisons of age-1, age-2 and age-3 growth.

In Upper Rush, the average length-at-age-1 in 2015 was 19 mm greater than the average length-at-age-1 in the Bottomlands section (Table 29). No data were available to allow comparisons with earlier sampling years.

In the Bottomlands section, age-2 brown trout recaptured in 2015 had lengths (197-239 mm) greater than the single fish caught in 2014 (219 mm) and greater than age-2 fish caught in 2013 (Table 29). The average length-at-age-2 in the Bottomlands in 2015 was greater than the length-at-age-3 in 2013 (Table 29). In Upper Rush, the only age-2 fish were recaptured in 2015 and no comparisons of length-at-age were made between previous sampling years. The 2015 lengths-at-age-2 in Upper Rush was similar to the Bottomlands (Table 29).

In 2015, no PIT tagged age-3 or age-4 brown trout were captured in the Bottomlands or Upper Rush sampling sections.

In the main channel of Lee Vining Creek age-2 brown trout in 2015 were on average, 9 mm larger than similar age fish in 2014 (Table 29). In 2015, the age-3 brown trout in Lee Vining Creek were on average, 23 mm smaller than similar age fish in 2014 and 38 mm shorter than similar age fish in 2013 (Table 29). No PIT tagged age-4 or age-5 brown trout have been recaptured in Lee Vining Creek (Table 29).

For Walker Creek in 2015, no length-at-age comparions were possible for age-1 and age-2 brown trout (Table 29). In 2015, age-3 brown trout in Walker Creek were, on average, similar in size to the same age fish in 2014 and 2013 (Table 29). In 2015 age-3 brown trout were, on average, larger than the same age fish in 2014 and 2013, by 38 and 30 mm, respectively (Table 29).

These findings of average lengths by age-class appear to support the previous conclusions by the Stream Scientist that very few brown trout reach age-4 or older on Rush Creek or Lee Vining Creek. Also, the low growth rates that brown trout exhibited in Rush Creek during three of the four dry runoff years make it highly unlikely that many fish survive long enough to attain lengths ≥300 mm, the size class approaching the metrics of the pre-1941 fishery.

Table 29. Size range of PIT tagged fish recaptured in 2015 by age class for brown trout at three electrofishing sections on Rush and Walker Creeks and for brown trout and rainbow trout on Lee Vining Creek. NOTE*:* when available, values from 2013 and 2014 provided for comparison.

Section	Cohort	Size Range (mm)	Average Length (mm)
Upper Rush	Age-1	**2015** = 169-203	**2015** = 187
	Age-2	**2015** = 205-242	**2015** = 217
	Age-3	**2015**=N/A **2014**=226-236 **2013**=227-263	**2014**=231 **2013**=245
	Age-4	**2015**=N/A **2014**=288 **2013**=252-255	**2014**=288 **2013**=254
	Age-5	**2015**=N/A **2014** = 298	**2014** = 298
Bottomlands	Age-1	**2015=**150-181	**2015=**169
	Age-2	**2015**=197-239 **2014**=192 **2013**=156-196	**2015=**219 **2014**=192 **2013**=178
	Age-3	**2015**=N/A **2014**=194 **2013**=194-227	**2014**=194 **2013**=204
	Age-4	**2015**=N/A **2014** = 215-219	**2014** = 216
	Age-5	None captured in past three years	
Walker Creek	Age-1	**2015** = 133-177	**2015** = 154
	Age-2	**2015**=N/A **2014**=168-200 **2013**=181-208	**2014**=186 **2013**=197
	Age-3	**2015**=211-231 **2014**=207-222 **2013**=219-221	**2015=**219 **2014**=217 **2013**=220
	Age-4	**2015=**249 **2014**=211 **2013**=219	**2015=**249 **2014**=211 **2013**=219
	Age-5	**2015=** N/A **2014**=220	**2014**=220
Brown Trout in Lee Vining Main Channel	Age-1	**2015=**149-190	**2015=166**
	Age-2	**2015=**176-214 **2014=**174-195 **2013=**206-225	**2015=**197 **2014=**188 **2013=**215
	Age-3	**2015=**188-228 **2014=**234-241 **2013=**238-271	**2015=**215 **2014=**238 **2013=**253
	Age-4	None captured in past three years	
	Age-5	None captured in past three years	
Rainbow Trout in Lee Vining Main Channel	Age-1	**2015** = 140-177	**2015** = 157
	Age-2	**2015=**195-216 **2014=**201-229	**2015=**204 **2014=**215
	Age-3	None captured in 2015	
	Age-4	None captured in 2015	
	Age-5	None captured in past three years	

Summer Water Temperature

During 2015, no data were available at the Rush Creek “Old Highway 395” location due to a lost data logger. Also in 2015, the data logger deployed in Rush Creek “At Damsite” stopped recording data on March 25th, thus no summer water temperature data were available from Rush Creek upstream of GLR. Although water temperatures were recorded year-round during 2015, summer water temperatures in July-September were more closely examined due to influences of warm temperatures on trout growth and condition factor (Table 30).

Compared to 2013 and 2014, the 2015 water temperatures in Rush Creek downstream of the MGORD were not as severe. In both 2014 and 2015, there were 20 days of daily maximum water temperatures above 70°F at the “Bottom of MGORD” monitoring location (Table 30). However, farther downstream at “Below Narrows” and “County Road” the total number of days with peak temperatures above 70°F were two days in 2015, compared to 70 days in 2014 (Table 30). While Rush Creek experienced high diurnal fluctuations during the summers of 2013 and 2014; these fluctuations were lower during the summer of 2015 (Table 30). In 2015, the summer water temperature metrics in Lee Vining Creek were similar to the previous year, and well within acceptable levels for brown trout and rainbow trout (Table 30).

Table 30. Summary of water temperature data during the summer of RY 2015 (July to September). Averages were calculated for daily mean, daily maximum, and daily minimum temperatures between July 1st and September 30th. All temperature data are presented in °F. Values for 2013-2014 are provided for comparison.

Temperature Monitoring Location	Daily Mean (°F)	Ave Daily Minimum (°F)	Ave Daily Maximum (°F)	No. Days > 70°F	Max Diurnal Fluctuation (°F)	Date of Max. Fluct.
Rush Ck. – Top of MGORD	**2015 = 64.4** 2014 = 64.8 2013 = 63.1	**2015 = 64.1** 2014 = 64.6 2013 = 62.6	**2015 = 64.8** 2014 = 65.0 2013 = 63.7	**2015 =0** 2014 = 0 2013 = 0	**2015 = 2.1** 2014 = 3.9 2013 = 3.4	**7/03/15** 8/13/14 7/09/13
Rush Ck. – Bottom MGORD	**2015 = 64.4** 2014 = 64.8 2013 = 63.2	**2015 = 62.3** 2014 = 62.9 2013 = 60.9	**2015 = 68.0** 2014 = 68.5 2013 = 67.1	**2015 = 20** 2014 = 20 2013 = 1	**2015 = 8.4** 2014 = 8.3 2013 = 9.0	**7/06/15** 7/13/14 7/09/13
Rush Ck. – below Narrows	**2015 = 62.3** 2014 = 63.2 2013 = 61.2	**2015 = 58.8** 2014 = 57.1 2013 = 56.2	**2015 = 66.1** 2014 = 69.4 2013 = 67.6	**2015 = 0** 2014 = 46 2013 = 24	**2015 = 11.5** 2014 = 17.3 2013 = 16.3	**9/23/15** 7/26/14 7/19/13
Rush Ck. – County Road	**2015 = 62.1** 2014 = 62.0 2013 = 61.4	**2015 = 59.1** 2014 = 56.7 2013 = 56.5	**2015 = 65.5** 2014 = 67.8 2013 = 66.6	**2015 = 2** 2014 = 24 2013 = 7	**2015 = 9.2** 2014 = 17.6 2013 = 14.7	**7/28/15** 7/26/14 8/02/13
Lee Vining – at intake	**2015 = 54.0** 2014 = 53.8 2013 = 52.1	**2015 = 49.7** 2014 = 49.9 2013 = 46.9	**2015 = 59.1** 2014 = 58.5 2013 = 58.0	2015 =0 2014 = 0 2013 = 0	**2015 = 14.0** 2014 = 13.0 2013 = 17.7	**7/29/15** 7/23/14 9/19/13
Lee Vining – at County Road	**2015 = 55.5** 2014 = 54.9	**2015 = 51.4** 2014 = 51.4	**2015 = 59.6** 2014 = 59.6	2015 = 0 2014 = 0	**2015 = 11.2** 2014 = 11.6	7/29/15 7/01/14

Similar to the 2013 and 2014 annual reports, a closer examination of the 2015 Rush Creek summer water temperature data was done by classifying daily average temperatures as either: 1) good potential growth days, 2) fair potential growth days, 3) poor potential growth days (daily averages within one degree or less of a "bad thermal day"), or 4) bad thermal days (Table 31). Development of the daily average temperature ranges which defined these "thermal days" was fully described in the previous annual report (Taylor 2015). Using these daily average metrics, good growth potential days in 2015 varied from seven to 25 days in Rush Creek out of the 92-day period from July 1 to September 30. Nearly all of these "good" days occurred in mid to late September. Within the MGORD, the numbers of "good" days in 2015 were similar to 2014, but at the lower temperature monitoring locations, the number of "good" thermal days increased in 2015, including an 85% increase at "Below Narrows" (Table 31). The days designated as "fair" occurred primarily in July and September. The "poor" days and "bad" thermal days were mostly clustered in late-July through most of August. At the two MGORD locations, compared to 2014, in 2015 there was a consistent shift towards more "fair" and "bad" thermal days; and decreases in the number of "poor" days (Table 31). At both MGORD locations, the numbers of "bad" thermal days have increased over the past three consecutive years, and in 2015 these "bad" days comprised more than 60% of the three summer months (Table 31). Consistently lower storage levels in GLR during the summers of 2013 - 2015 most likely influenced this shift in "bad" thermal days.

Table 31. Classification of runoff years 2013, 2014 and 2015 water temperature data into good growth days, fair growth days, poor growth days and bad thermal days based on daily average temperatures (92-day period from July 1 to September 30). The percent (%) designates each thermal day-type's occurrence for the 92-day summer period.

Temperature Monitoring Location	No. of Days for Good Growth Potential – Daily Ave. 55.5° - 60.5°F	No. of Days for Fair Growth Potential – Daily Ave. 60.6° – 63.9°F	No. of Days of Poor Growth Potential – Daily Ave. 64.0° - 64.9°F	No. of Bad Thermal Days - Daily Ave. ≥65°F
Rush Ck. – Top of MGORD	2013 = 14 (15%) 2014 = 5 (6%) **2015 = 7 (8%)**	2013 = 43 (47%) 2014 = 14 (15%) **2015 = 20 (22%)**	2013 = 17 (18%) 2014 = 25 (27%) **2015 = 5 (5%)**	2013 = 18 (20%) 2014 = 48 (52%) **2015 = 60 (65%)**
Rush Ck. – Bottom MGORD	2013 = 11 (12%) 2014 = 6 (6%) **2015 = 8 (9%)**	2013 = 38 (41%) 2014 = 11 (12%) **2015 = 20 (22%)**	2013 = 20 (22%) 2014 = 21 (23%) **2015 = 5 (6%)**	2013 = 23 (25%) 2014 = 54 (59%) **2015 = 59 (64%)**
Rush Ck. – Below Narrows	2013 = 17 (18%) 2014 = 13 (14%) **2015 = 24 (26%)**	2013 = 69 (75%) 2014 = 58 (63%) **2015 = 44 (48%)**	2013 = 6 (7%) 2014 = 18 (20%) **2015 = 22 (24%)**	2013 = 0 2014 = 3 (3%) **2015 =2 (2%)**
Rush Ck. – County Road	2013 = 17 (18%) 2014 = 17 (18%) **2015 = 25 (27%)**	2013 = 64 (70%) 2014 = 59 (65%) **2015 = 39 (42%)**	2013 = 8 (9%) 2014 = 14 (15%) **2015 =23 (25%)**	2013 = 3 (3%) 2014 = 2 (2%) **2015 = 5 (6%)**

As was done with the 2013 and 2014 data, the diurnal temperature fluctuations for July–September 2015 were characterized by the one-day maximum fluctuation that occurred each month and by monthly averages (Table 32). Also, for each temperature monitoring location, the highest average diurnal fluctuation over a consecutive 21-day duration was determined (Table 32). While the 2013 and 2014 analyses consistently depicted high diurnal fluctuations at the Below Narrows and County Road temperature monitoring locations; the 2015 data documented more moderate fluctuations. For all months, the one-day maximum and monthly average fluctuations at the Below Narrows and County Road locations were consistently lower in 2015, compared to 2014 (Table 32). In 2014, the 21-day duration values for the Below Narrows and County Road locations exceeded the 12.6°F tolerance limit defined by Werley et al. (2007); however in 2015 this tolerance level was never approached (Table 32). At both MGORD locations, the 2015 diurnal fluctuations were similar to the 2014 values (Table 32). Inflow from GLR entered the top of the MGORD warm and varied little throughout the summer. For example, in July and August, daily minimum temperatures ranged from 64.6 to 66.9°F and daily maximums were from 65.1 to 67.4°F.

Table 32. Diurnal temperature fluctuations in Rush Creek for 2015: maximum daily for month, daily average for month, and highest average for consecutive 21-day duration (92-day period from July 1 to September 30). NOTE: 2014 values in ( ) for comparison.

Temperature Monitoring Location	Maximum and Average Daily Diurnal Fluctuation for July	Maximum and Average Daily Diurnal Fluctuation for August	Maximum and Average Daily Diurnal Fluctuation for September	Highest Average Diurnal Fluctuation for a Consecutive 21-Day Duration
Rush Ck. – Top of MGORD	Max = 2.1°F (3.9) Ave = 0.9°F (0.9)	Max = 1.4°F (1.0) Ave = 0.7°F (0.3)	Max = 1.2°F (1.3) Ave = 0.5°F (0.5)	0.9°F (1.1) July 3-23
Rush Ck. – Bottom MGORD	Max = 8.4°F (8.3) Ave = 5.8°F (6.1)	Max = 7.3°F (6.8) Ave = 5.8°F (5.4)	Max = 6.4°F (6.8) Ave = 5.2°F (5.4)	6.1°F (6.4) Aug 2-22
Rush Ck. – below Narrows	Max = 10.0°F (17.3) Ave = 6.0°F (12.7)	Max = 10.1°F (16.1) Ave = 8.0°F (12.5)	Max = 11.5°F (15.2) Ave = 7.8°F (11.8)	8.5°F (14.1) Aug 8 – 28
Rush Ck. – County Road	Max = 9.2°F (17.6) Ave = 6.5°F (10.1)	Max = 8.4°F (15.6) Ave = 6.5°F (12.2)	Max = 7.5°F (15.4) Ave = 6.1°F (11.2)	7.5°F (13.9) July 15 - Aug 4

The thermal window bounded by 66.2-71.6°F where brown trout may be physiologically stressed and living at the edge of their survival tolerance was quantified for each Rush Creek temperature monitoring location. The hourly temperature data for the 92-day (or 2,208-hour) summer period were sorted from low to high and the number of hours where temperatures exceeded 66.2°F were summed by month and entire summer period (Table 33). The values from 2013 and 2014 were also included in Table 33 to better illustrate the variability that occurred at all the temperature monitoring locations. The 2015 data show that all the temperature monitoring locations were within the 66.2-71.6°F thermal window for 13% to 27% of the 92-day summer period. Between 2014 and 2015, the two MGORD locations experienced modest decreases in the number of hourly temperatures ≥66.2 °F for the entire 92-day summer period; -16% for Top of MGORD and -6% for Bottom of MGORD (Table 33). Between 2014 and 2015, the Below Narrows and County Road locations both experienced 40% decreases in the number of hourly temperatures ≥66.2 °F for the entire 92-day period (Table 33). Consistent with the 2013 and 2014 data, the 2015 data also confirmed a sizeable warming trend as streamflow travelled down the MGORD (Table 33).

Table 33. Number of hours that temperature exceeded 66.2°F in Rush Creek: by month and for 92-day period from July 1 to September 30, 2013 - 2015. Percent (%) designates amount of month or summer where hourly temperatures exceeded 66.2°F.

Temperature Monitoring Location	Number of Hours Temperature exceeded 66.2°F in July (744 hours)	Number of Hours Temperature exceeded 66.2°F in August (744 hours)	Number of Hours Temperature exceeded 66.2°F in Sept. (720 hours)	Number of Hours Temperature exceeded 66.2°F in 92-day period
Rush Ck. – Top of MGORD	2013 = 4 hrs (0.5%) 2014 = 315 hrs (42%) **2015 = 140 hrs (19%)**	2013 = 4 hrs (0.5%) 2014 = 96 hrs (13%) **2015 = 205 hrs (28%)**	2013 = 0 hrs 2014 = 0 hrs **2015 = 0 hrs**	2013 = 8 hrs (0.4%) 2014 = 411 hrs (19%) **2015 = 345 hrs (16%)**
Rush Ck. – Bottom MGORD	2013 = 121 hrs (16%) 2014 = 282 hrs (38%) **2015 = 305 hrs (41%)**	2013 = 229 hrs (31%) 2014 = 248 hrs (33%) **2015 =282 hrs (38%)**	2013 = 61 hrs (9%) 2014 = 115 hrs (16%) **2015 =17 hrs (2%)**	2013 = 411 hrs (19%) 2014 = 645 hrs (29%) **2015 = 604 hrs (27%)**
Rush Ck. – below Narrows	2013 = 158 hrs (21%) 2014 = 244 hrs (33%) **2015 = 129 hrs (17%)**	2013 = 192 hrs (26%) 2014 = 193 hrs (26%) **2015 = 189 hrs (25%)**	2013 = 55 hrs (7%) 2014 = 105 hrs (15%) **2015 = 0 hrs (0%)**	2013 = 405 hrs (18%) 2014 = 542 hrs (25%) **2015 = 318 hrs (14%)**
Rush Ck. – County Road	2013 = 197 hrs (27%) 2014 = 222 hrs (30%) **2015 = 174 hrs (23%)**	2013 = 172 hrs (23%) 2014 = 195 hrs (26%) **2015 = 119 hrs (16%)**	2013 = 42 hrs (6%) 2014 = 79 hrs (11%) **2015 = 0 hrs (0%)**	2013 = 411 hrs (19%) 2014 = 496 hrs (23%) **2015 = 293 hrs (13%)**

Compared to 2014, the improvement of 2015 temperature metrics in lower Rush Creek appeared counterintuitive given that GLR storage was lower and had the potential to be more susceptible to thermal loading (Figure 4). However, late spring and early summer weather conditions during 2015 may have ameliorated the thermal loading within GLR (Table 34). Late rain and snowfall resulted in near-record precipitation in May of 2015, which also coincided with cooler air temperatures (Table 36). July of 2015 was also cooler compared to July of 2014; with the monthly average minimum temperature 3.5°F lower and the monthly average maximum temperature 6.6°F lower in 2015 versus 2014 (Table 34).

Table 34. Summary of monthly air temperature and precipitation data during May-September of 2014 and 2015, as recorded by NOAA at the Lee Vining airport (station #USC00044881).

Month of Data Collection	Monthly Ave Minimum Air Temperature (°F)	Monthly Ave Maximum Air Temperature (°F)	Monthly Precip Total for Rain and/or Melted Snow (inches)	Monthly Precip Total for Snow, Ice and/or Hail (inches)
May	2014 = 40.3 2015 = 38.7	2014 = 68.9 2015 = 61.5	2014 = 0.37” 2015 = 4.15”	2014 = 0 2015 = 15.0”
June	2014 = 48.6 2015 = 50.9	2014 = 79.2 2015 = 79.9	2014 = 0.54” 2015 = 0.61”	2014 = 0 2015 = 0
July	2014 = 55.4 2015 = 51.9	2014 = 85.4 2015 = 78.8	2014 = 0.86” 2015 = 2.08”	2014 = 0 2015 = 0
August	2014 = 51.2 2015 = 53.2	2014 = 80.6 2015 = 84.0	2014 = 1.01” 2015 = 0.15”	2014 = 0 2015 = 0
September	2014 = 47.4 2015 = 47.7	2014 = 78.1 2015 = 79.5	2014 = 1.03” 2015 =0.23”	2014 = 0 2015 = 0

Discussion

The 2015 sampling year was highlighted by the extended drought conditions that persisted throughout most of California. Within the Mono Basin the 2015 runoff year was 25% of normal and classified as a dry runoff year type. This was the fourth consecutive dry runoff year type (RY 2014 was 48% of normal, RY 2013 was 66% of normal and RY 2012 was 55% of normal). Calendar year 2015 was also marked by LADWP, the Mono Lake Committee, California Trout, and the California Department of Fish and Wildlife continuing to translate the new settlement terms (signed in September 2013) into enforceable license language prior to issuance of amended licenses by the State Water Resources Control Board.

The past two Annual Fisheries Report’s Discussion sections were focused on the 2013 and 2014 summer thermal regimes in Rush Creek and the potential effects of summer water temperature on trout growth, condition factor and survival. Because 2015 was marked by a fourth dry year, this report’s Discussion will focus on similar analyses. Before discussing the 2015 water temperature data, fish growth and condition factor results; a summary of trout population metrics is provided.

Sampling Section Summaries for Four Dry RYs

By sample section, the following bulleted list summarizes noteable trout population metrics that have occurred during the dry RY conditions that have persisited for the past four years in the Mono Lake watershed. On Rush Creek, the three sections are listed in a downstream direction.

Rush Creek – MGORD

- Poor thermal conditions have persisted for the past three summers. The number of “bad” thermal days increased each of the past three years, with more than 60% bad thermal days during the summer of 2015.
- Low numbers of total fish captured. Between 2012 and 2015, the catch dropped from 575 fish (average of two passes) to 176 fish (single pass), a 70% decline.
- Low numbers of larger brown trout. Between 2012 and 2014, the catch of trout ≥300 mm dropped from 199 fish to 29 fish, an 85% decline. These were both two-pass sampling years.
- In 2015, PIT tagged fish that were recaptured all experienced positive growth between 2014 and 2015.
- Condition factor below average (<1.00) for all four dry RYs.

Rush Creek – Upper

- Low numbers of total fish captured. Between 2012 and 2015, the total population estimate dropped from 3,564 fish to 1,058 fish, a 70% decline.
- Low numbers of age-0 brown trout. Between 2012 and 2015, the population estimate of brown trout <125 mm has decreased by 78%.
- In 2015, PIT tagged age-1 and age-2 fish that were recaptured experienced good growth between 2014 and 2015.
- Condition factor below average for all four dry RYs.

Rush Creek – Bottomlands

- Low numbers of total fish captured. Between 2012 and 2015, the total population estimate dropped from 1,402 fish to 623 fish, a 56% decline. Between 2012 and 2014, the total population estimate decreased by 66%.
- Low numbers of age-0 brown trout. Between 2012 and 2015, the population estimate of brown trout <125 mm has decreased by 45%. Between 2012 and 2014, the age-0 population estimate decreased by 79%.
- In 2015, PIT tagged age-1 and age-2 fish that were recaptured experienced good growth between 2014 and 2015.
- Condition factor below average for all four dry RYs.

Walker Creek

- Lower numbers of total fish captured. Between 2012 and 2015, the total population estimate dropped from 1,402 fish to 623 fish, a 37% decline.
- Lower numbers of age-0 brown trout. Between 2012 and 2015, the population estimate of brown trout <125 mm has decreased by 52%.
- In 2015, recaptured PIT tagged age-1 and age-2 fish experienced better growth than the same age fish recaptured in 2013 and 2014.
- Condition factor below average for two of the four dry RYs. Average for the other two RYs (1.00 and 1.01).

Lee Vining Creek – Main Channel

- Lower numbers of total fish captured. Between 2012 and 2015, the total brown trout population estimate dropped from 797 fish to 495 fish, a 38% decline.
- Lower numbers of age-0 brown trout. Between 2012 and 2015, the population estimate of brown trout <125 mm decreased each year. From 2012 to 2015, the estimate went from 677 age-0 brown trout to 250 fish, a 63% decline.
- PIT tagged age-1 and age-2 fish that were recaptured experienced average growth between 2014 and 2015.
- Condition factor of brown trout and rainbow trout below average for three of the four dry RYs. In the 12 sampling years prior to 2012, condition factors were always >1.00.
- Rainbow trout numbers in severe decline between 2012 and 2015. In 2012, a total of 235 rainbow trout were captured (226 age -0 fish) and in 2015 only 20 rainbow trout were caught (no age-0 fish), for a 91% decline. This dramatic drop is worrisome because rainbow trout (as spring spawners) have typically flourished in Lee Vining Creek during drier RYs when peak flows were too small to mobilize the channel bed and disrupt incubating eggs or alevins.

Lee Vining Creek – Side Channel

- Reduced streamflow to the side channel has resulted in smaller wetted area for fish sampling. Between 2012 and 2015, the wetted channel area has decreased from 365 m^2 to 70.3 m^2, an 81% decrease.
- Lower numbers of total fish captured. Between 2012 and 2015, the total trout catch has dropped from 45 fish to seven fish, an 84% decline.
- Lower numbers of age-0 brown trout. No age-0 brown trout captured in 2014 and 2015. Only one age-0 brown trout captured in 2012.
- No age-0 rainbow trout captured in side channel in past seven years and no age-1 and older rainbow trout captured in the past five years.

2015 Summer Water Temperature Data

As presented in the Results section, the poor to marginal water temperatures recorded in Rush Creek during the summers of 2013 and 2014 also occurred during the summer of 2015. Lower GLR storage in 2015 translated into a pool of warm water (with little diurnal fluctuation) that was released into the top of the MGORD. In terms of brown trout growth and condition, water temperature metrics within the MGORD were poor and worsened in a downstream direction within the 1.2 mile length of the MGORD. Brown trout numbers in the MGORD appear to reflect these poor thermal conditions with a 70% decline in total catch numbers between 2012 and 2015. Also, over this four-year stretch the numbers of large trout (>300 mm) sampled has dropped by 85%. To put this recent drop in numbers of brown trout >300 mm into a long-term perspective, between 2001 and 2012, an average of 90 trout >300 mm were captured versus 19 trout >300 mm between 2013 and 2015 (a 79% decline). Visually, the eldoa beds within the MGORD have appeared impacted by the extended drought. Prior to the drought, the eloda beds during the summer months were lush with vibrant green floating mats that provided cover for trout, as well as surface area for abundant populations of scuds and caddisflies. The past three summers, the eloda beds have appeared stunted, covered in fine sediment, and lacking the growth of floating, trailing surface mats. A qualitative snorkel survey conducted in September of 2015 also suggests that numbers of scuds and caddisflies (important trout food items) were low, relative to pre-drought snorkel observations.

The improvement in Rush Creek water temperature metrics documented at the Below Narrows and County Road locations were most likely attributed to cooler air temperatures and late season precipitation (Table 34). Compared to the two previous summers, these water temperature monitoring locations in lower Rush Creek recorded fewer days with peak temperatures >70^{o}F and smaller diurnal fluctuations in 2015.

Trout Growth Rates in 2015

Between 2014 and 2015, reductions in diurnal fluctuations, the total number of days with peak temperatures above 70°F, and the total number of hours within the thermal window bounded by 66.2-71.6^{o}F were documented at the Below Narrows and County Road temperature monitoring locations. The improvement of these summer water temperature metrics may have translated into improved growth of age-1 and age-2 brown trout, as confirmed by growth rates of recaptured PIT tagged fish and by the average weights calculated from all fish caught during the 2015 mark-and-recapture sampling.

The growth rates of age-1 fish in 2015 were comparable to pre-drought growth rates (2008-2011); with average weight gains of 55 g in Upper Rush and 41 g in the Bottomlands (Table 35). Unfortuanately no age-1 growth rates were calculated in 2014 due to a lack of PIT tag recaptures (Table 35). The growth rates for age-2 fish in 2015 were also comparable to pre-drought growth rates; with average weight gains of 69 g in Upper Rush and 62 g in the Bottomlands (Table 35). Again, very few PIT tag recaptures of age-2 fish occurred in 2014 to allow robust comparisions with the 2015 growth rates (Table 35). No growth information was available for age-3 fish because of the small number of tags deployed in 2012 (Table 35). For age-1 and age-2 brown trout, the 2015 weight gains were either the highest for Upper Rush and Bottomlands section since PIT tagging started or were the highest for the four consecutive dry RYs (Table 35).

Examination of average weights of three size classes of brown trout caught during the past three sampling years confirms better growth in 2015 versus 2014 and 2013 (Table 36). In the Upper Rush section, the two smaller size classes of brown trout were, on average, larger in 2015 than in 2014 and 2013 (Table 36). In the Bottomlands section, brown trout in the <125 mm size class had similar average weights in 2013 and 2014, but approximately a 50-55% gain in 2015. For the ≥200 mm size class, Upper Rush experienced a slight decrease between 2014 and 2015, whereas the Bottomlands had a 29% increase due to an increase catch of trout >225 mm in length (Table 36). The 2014 average weight of brown trout ≥200 mm in the Bottomlands of 88.5 g excluded a large trout (444mm/1040g) that had moved down from the MGORD because this one fish had such a great influence on the average (122.5 g when included). Similarly, the 2015 average weight of brown trout ≥200 mm in the Bottomlands of 114.4 g excluded a large trout (470mm/1089g) because this one fish had such a great influence on the average (132.1 g when included).

Table 35. Growth rate (g) comparisons of Rush Creek age-0 to age-1, age-1 to age-2, and age-2 to age-3 brown trout, by years.

Age Class	Growth Years	Upper Rush Growth (g)	Bottomlands Growth (g)	Fin clip or PIT Tag
Age-0 to Age-1	2006-2007	32	N/A	Ad Clip
	2008-2009	51	43	Ad Clip
	2009-2010	48	40	PIT Tag
	2010-2011	48	36	PIT Tag
	2011-2012	33	25	PIT Tag
	2012-2013	35	25	PIT Tag
	2013-2014	N/A	N/A	N/A
	2014-2015	55	41	PIT Tag
Age-1 to Age-2	2008-2009	N/A	N/A	Ad Clip
	2009-2010	70	54	PIT Tag
	2010-2011	73	32	PIT Tag
	2011-2012	42	28	PIT Tag
	2012-2013	42	22	PIT Tag
	2013-2014	N/A	29*	PIT Tag
	2014-2015	69	62	PIT Tag
Age-2 to Age-3	2010-2011	N/A	14	PIT Tag
	2011-2012	29	16	PIT Tag
	2012-2013	N/A	9	PIT Tag
	2013-2014	41**	31**	PIT Tag
	2014-2015	N/A	N/A	PIT Tag

*one fish **two fish

Another likely influence on the improved growth rates of younger brown trout over the past several years may be related to the reduced numbers of trout. Density-dependent growth in stream-dwelling salmonids is well researched and there's broad support for the hypothesis that density-dependent growth occurs at low population densities, probably due to exploitive completion (Grant and Imre 2005). One study used controlled reaches of a small stream and determined that population density affected growth in trout parr (yearlings and older) and that competition and population regulation was not just limited to early life-stages, as suggested by other researchers (Bohlin et al. 2002). Another analysis used data collected from 19 trout populations (six species and 16 different studies) and determined that 15 of the 19 populations showed evidence of decreased growth rates with increasing densities (Grant and Imre 2005). This analysis was focused primarily on age-0 trout (Grant and Imre 2005). For Upper Rush, ten years (2006-2015) of age-0 brown trout and total brown trout population estimates were plotted versus the average weights of age-0 brown trout from those sample years (Figure 25).

Trend lines through each of the population estimates strongly suggest density-dependent growth of age-0 fish has occurred in the Upper Rush section (Figure 25). When average weights of older ages were plotted, density-dependent growth was less apparent in the Upper Rush section. In fact, when average weights of brown trout ≥200 mm were plotted against ten years of total population estimates, the trend line increased, although the R^2 value was low (Figure 26).

Table 36. Average weight comparisons of Rush Creek brown trout, in three size classes captured in 2013 and 2014.

	Upper Rush Section			Bottomlands Section		
Size Class	**2013 Ave Weight (g)**	**2014 Ave Weight (g)**	**2015 Ave Weight (g)**	**2013 Ave Weight (g)**	**2014 Ave Weight (g)**	**2015 Ave Weight (g)**
<125 mm	7.2	9.0	12.6	7.0	6.7	10.4 g
125-199 mm	43.1	47.2	52.3	37.0	39.8	45.5
≥200 mm	119.0	131.6	126.8	84.2	88.5*	114.4**

*Excludes 444mm/1040g trout. **Excludes 470mm/1,089g trout.

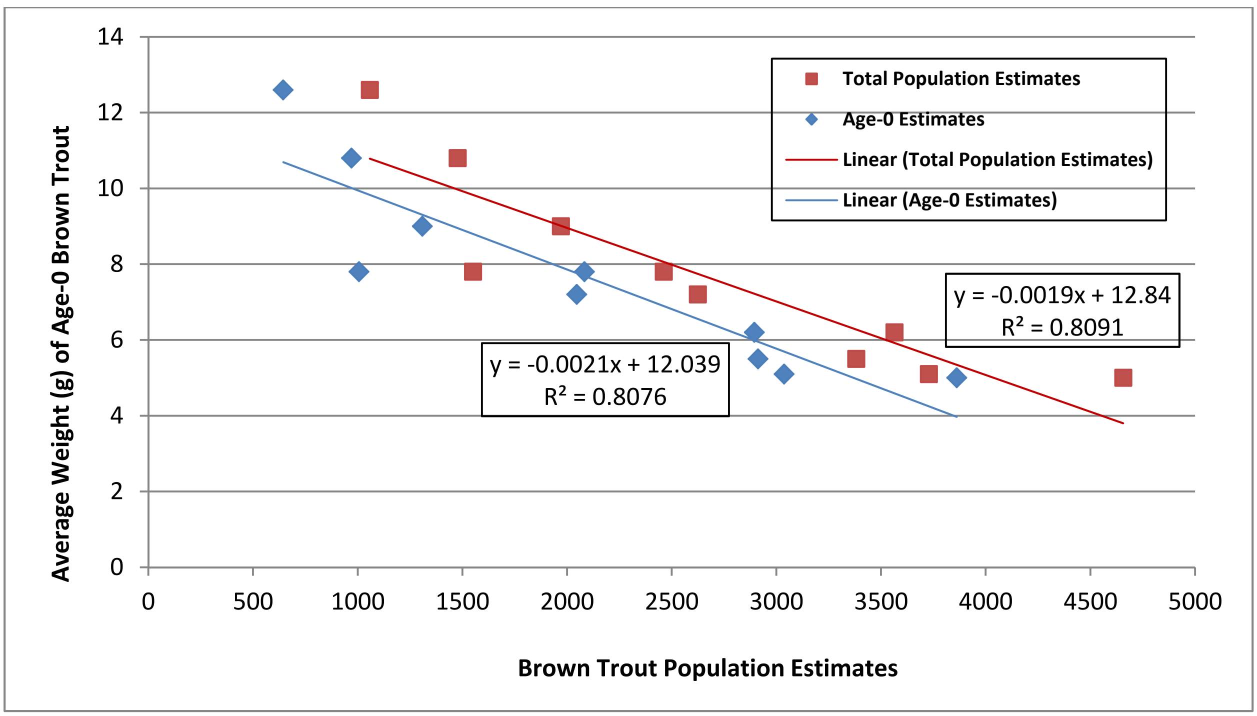

Figure 25. Relationship between average weights of age-0 brown trout and population estimates (age-0 and all trout) in the Upper Rush sampling section, 2006-2015.

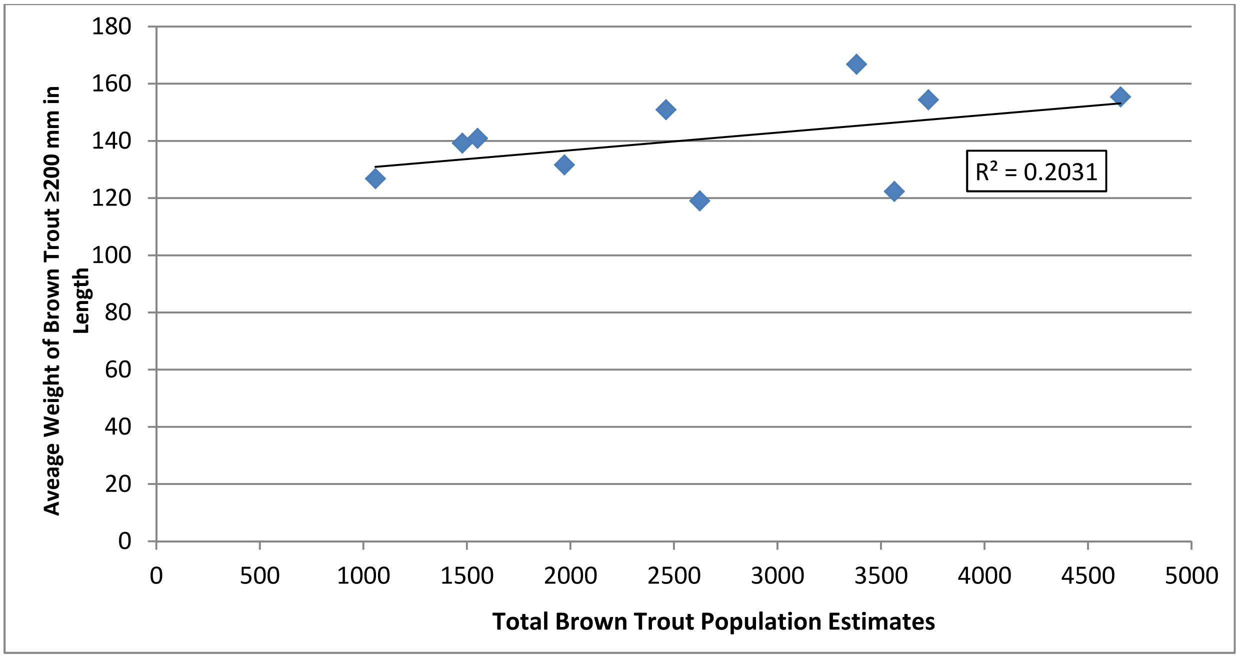

Figure 26. Relationship between average weights brown trout ≥200 mm in length and total population estimates in the Upper Rush sampling section, 2006-2015.

In 2014, 238 brown trout between 150 and 299 mm were PIT tagged in the MGORD and in 2015 six of these fish were recaptured to gauge the 2015 growth rates of trout less than 300 mm in length. The average growth rates of these fish were 66 mm in length and 231 g in weight. Only one fish in the 301-375 mm size class was recaptured in 2015 and this one fish exhibited good growth (Table 28). Brown trout in the >375 mm size class exhibited better growth rates (781 g) in 2015 than in the previous five years (Table 28). Unlike previous years, in 2015 no large trout lost weight as they aged (Tables 28 and 29). However, these improved growth rates of larger brown trout coincided with the lowest number of fish >300 mm captured in the MGORD over the 12 seasons it has been sampled (for both single-pass and two-pass sampling efforts). In 2015, only 29 fish >300 mm in length were captured on the single electrofishing pass.

The RSD-300 metric was developed in part to gauge the ability of Rush Creek to produce brown trout that were ≥12 inches in length, allowing comparison to the D-1631 statement that, *"prior to water diversions on Rush Creek, brown trout averaging thirteen to fourteen inches were regularly observed"*. In the Upper Rush section, a total of 89 brown trout ≥300mm have been captured in 16 seasons, an average of 5.6 fish per year. In the Bottomlands section, a total of nine brown trout ≥300 mm have been caught in eight sampling years, an average of 1.1 fish per year. In the County Road section, a total of 11 brown trout ≥300 mm were captured in 14 seasons, an average of 0.8 fish per year. The only section of Rush Creek where brown trout ≥300 mm were regularly observed was in the MGORD. A total of 1,732 brown trout ≥300mm were captured in the MGORD during 12 sampling seasons for an average of 141.9 fish per year.

Age-0 Recruitment in Rush Creek

The availability and location of spawning habitat in Rush Creek was a concern during the development of Decision 1631 and subsequent SWRCB Orders 98-05 and 98-07. The Mono Basin EIR noted that 55 redds were found between 1985 and 1989, primarily in the uppermost 0.85 miles of Rush Creek below GLR dam (page 3D-19). Section 5.4.2 of Decision 1631 (titled Flows for Providing Fishery Habitat) stated, "There is general agreement that adult habitat and spawning habitat in Rush Creek are limited." Much of the early instream flow recommendations centered on the stability of introduced spawning substrate. In contrast, our experience since 1999 after the fisheries sampling methods were established, was that annual recruitment of age-0 brown trout in the Rush Creek sections was variable, yet sufficient enough to translate into ample numbers of age-1 and older fish in subsequent years. Previous annual fisheries monitoring reports have shown that wide ranges in the numbers of age-0 brown trout produced in 2000-2004 eventually translated into similar numbers of age -1 and older fish (Hunter et al. 2004 and 2005). We also stated in the Synthesis Report that "In Rush Creek, ample recruitment of age-0 brown trout has occurred the past ten years."

During the past four Dry RY types, the numbers of age-0 brown trout have declined in both annually sampled sections of Rush Creek. In the Upper Rush section, the population estimate of age-0 brown trout has declined by 78% between 2012 and 2015. Age-0 brown trout in the Bottomlands section experienced a 79% decline in population estimate between 2012 and 2014, with a rebound between 2014 and 2015.

The four years of drought conditions have affected the trout in Rush and Lee Vining creeks, in terms of population numbers and condition factors. The total numbers of brown trout and larger (and older) fish in the MGORD are at all time lows. Drought effects on brown trout populations are well documented; however the effects and suspected causes are variable. James et al. (2010) documented 66% to 80% declines in brown trout biomass in three Black Hills streams in South Dakota between early-drought and late-drought periods. These declines were attributed to flow reductions and loss of pool volume since thermal conditions remained similar. A 30-year study (1966-1996) determined that drought periods lead to increased mortality and decreased growth of brown trout (Elliot et al. 1997). This study found that summer droughts which extended into the autumn spawning period resulted in lower densities of spawning females and viable eggs. Finally, another study examined resident brown trout confined to isolated pools during two years of drought (Elliot 2000). When compared to pre-drought data, the densities of age-0 and age-1 trout were reduced. The remaining fish utilized the deeper sections of the isolated pools as refugia; to the extent that a preference was detected for cooler water with lower levels of dissolved oxygen at the bottom of the pools versus the top layer of the same pools with higher temperatures, yet more dissolved oxygen (Elliot 2000).

Limited information was found concerning post-drought responses by stream dwelling trout populations. However, an assessment of naturally reproducing rainbow trout populations in Colorado on National Forest lands concluded that shortly after an extended period of drought

(2000-2004), rainbow trout numbers were at stable, or increased, levels due to the fish's wide distribution across multiple watersheds (Adams et al. 2008).

As of early April 2016, the preliminary RY forecast for 2016 is for a dry-normal II, 75.5% to 82.5% of average runoff. On April 1st the Mono Lake level was measured at 6,378.11 feet. As of April 5, 2016 GLR storage is also at 7,095 feet, close to its storage level in early April of 2015, just prior to when LADWP exported their allocated 4,500 acre-feet. Under the current Orders, Rush Creek should receive a peak discharge of 250 cfs for five days. Thus, it appears heading into the summer of 2016 that GLR will remain relatively low and thermal concerns will be again be an issue for brown trout in Rush Creek.

Methods Evaluation

In 2015, mark-recapture and depletion estimates were again used to produce population estimates on Rush Lee Vining and Walker Creeks. As in past years, we started off cleaning the block fences twice a day, but windy conditions and falling leaves resulted in block fence failures. After the upstream fences at Upper Rush and the Lee Vining Creek main channel failed several times each we implemented a more rigorous fence cleaning schedule. The relatively similar numbers of fish captured during both the mark and recapture runs suggest little, if any, movement of fish in or out of the sections during these brief fence failures.

While there were no major changes to the channels due to peak flows, between 2014 and 2015 there were decreases in average widths the Rush Creek Bottomlands section (-0.3 m), Walker Creek (-0.2 m), the Lee Vining Creek main channel (-0.7 m), and the Lee Vining Creek side channel (-0.5 m). These changes in average channel widths may be a function of where the individual measurements, as well as streamflow discharge at the time of measurement. As in 2014, much of the Lee Vining Creek side channel was dry in 2015. The wetted surface area in 2015 was reduced to 70.3 m^2. It is recommended that channel length and width be re-measured annually.

The PIT tagging program was continued during the September 2015 sampling and tags were implanted primarily in age-0 fish. Because less than 500 tags were implanted in 2012; the recapture of previously tagged age-3 fish was low in 2015. As previously mentioned, no tags were deployed in 2013, which also impacted recaptures of age-2 fish in 2015. These low recapture rates limited inferences about trout growth and survival during the fourth year of drought in the Mono Basin. Resumption (and continuation) of the PIT tagging program is important as the fisheries monitoring program moves towards its post-settlement phase.

Trout size classes (0-124, 125-199, and ≥200 mm) developed and discussed during the 2008 annual report should continue to be used in the future (Hunter et al. 2008). Using these size classes provides for long-term consistency as well as year to year consistency with the annual fisheries data sets.

To ensure that electrofishing sampling can be conducted safely and efficiently, flows in Rush and Lee Vining creeks not exceed 40 cfs. (± 5 cfs.) during the annual sampling period.

Allowances for flow variances to allow for safe wading conditions and effective sampling were included in the new Terms of Settlement.

Finally, during the spring and summer of 2015, water temperature data were missing from two key locations along Rush Creek. The data logger at the Old Highway 395 Bridge was lost during the 2015 season, thus no data were available. The second location where summer water temperature data were missed was Rush Creek at Dam Site, upstream of GLR. A data logger was placed at this location by LADWP, but only collected data until March 25th. Common reasons for data logger failure include loss of battery power, malfunction of internal circuitry and user error.

Prior to the summer of 2016, it is recommended that LADWP inspect their Onset© water temperature data loggers and replace any that are near the end of their suggested battery life. LADWP should also consider more frequent data downloads to ensure that all data loggers are functioning properly so that important summer water temperature data are not missed, as they were in 2015. Another issue with the 2015 water temperature monitoring was the data logger located at County Road. The timing of the diurnal fluctuations recorded at this location suggests that the time-stamp was incorrect, which can occur during either the launching or downloading process. Throughout most of the year, daily peak temperatures at this location occurred hours after sunset, even though all of the upstream data loggers recorded peaks in the early to mid-afternoon and cooling trends thereafter. When these other locations were cooling down, the County road data logger recorded increasing temperatures into the night, with peaks occurring as late as midnight to 1:00 AM. Whenever data loggers are downloaded, it is important to make sure that the shuttle's time and date stamp was properly synced prior to download.

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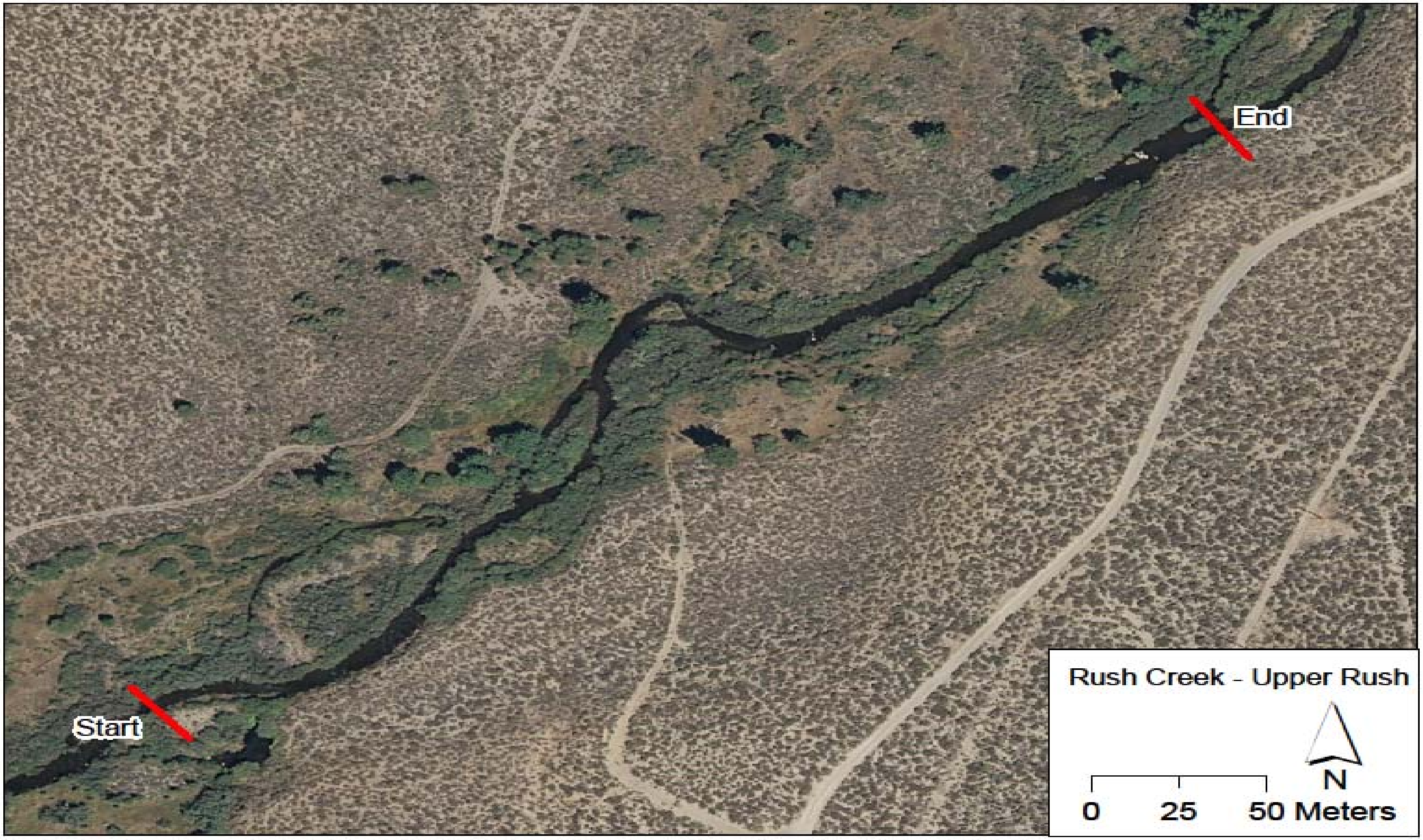
Appendices for the 2015 Mono Basin Annual Fisheries Report

Appendix A: Aerial Photographs of Long-term Monitoring Sections.




End
Start
Rush Creek - Bottomlands
N
0
25
50 Meters


End
Start
Rush Creek - MGORD
N
0
100
200 Meters


End
End
B-1 Side Channel
Main Channel
Start
Start
Lee Vining Creek- Main and B-1 Side Channels
0
20
40 Meters
N


End
Start
Walker Creek
N
0
12.5
25 Meters

Appendix B: Tables of PIT-tagged Fish Recaptured during the September 2015 Sampling

Appendix B: Table 1. PIT tagged trout recaptured in Rush Creek sections, September 2015.

Date of Recapture	Species	Length (mm)	Weight (g)	PIT Tag Number	Location of 2015 Recapture	Location of Initial Capture and Tagging
9/16/2015	BNT	174	55	989001001231700	Bottomlands	Bottomlands
9/16/2015	BNT	211	82	989001001239831	Bottomlands	Bottomlands
9/16/2015	BNT	235	115	989001001242577	Bottomlands	Bottomlands
9/16/2015	BNT	222	105	989001001356788	Bottomlands	**Upper Rush**
9/16/2015	BNT	172	46	989001001356926	Bottomlands	Bottomlands
9/16/2015	BNT	181	55	989001001357937	Bottomlands	Bottomlands
9/16/2015	BNT	150	29	989001001359231	Bottomlands	Bottomlands
9/16/2015	BNT	162	39	989001001359765	Bottomlands	Bottomlands
9/16/2015	BNT	252	155	989001001951220	Bottomlands	Bottomlands
9/16/2015	BNT	173	49	989001001951225	Bottomlands	Bottomlands
9/16/2015	BNT	239	121	989001001953478	Bottomlands	Bottomlands
9/16/2015	BNT	231	119	989001001953495	Bottomlands	Bottomlands
9/16/2015	BNT	202	75	989001001953872	Bottomlands	Bottomlands
9/16/2015	BNT	223	104	989001001954089	Bottomlands	Bottomlands
9/16/2015	BNT	197	78	989001001955071	Bottomlands	Bottomlands
9/16/2015	BNT	152	37	989001001955337	Bottomlands	Bottomlands
9/23/2015	BNT	185	61	989001001951232	Bottomlands	Bottomlands
9/23/2015	BNT	215	109	989001001955059	Bottomlands	Bottomlands
9/18/2015	BNT	423	794	985121017031639	MGORD	MGORD
9/18/2015	BNT	495	1334	985121021871652	MGORD	MGORD
9/18/2015	BNT	460	1224	985121021876593	MGORD	MGORD
9/18/2015	BNT	485	1324	985121023369646	MGORD	MGORD
9/18/2015	BNT	306	313	989001001231129	MGORD	MGORD
9/18/2015	BNT	340	442	989001001231237	MGORD	MGORD
9/18/2015	BNT	346	415	989001001237208	MGORD	MGORD
9/18/2015	BNT	335	384	989001001239659	MGORD	MGORD
9/18/2015	BNT	391	709	989001001357166	MGORD	MGORD
9/18/2015	BNT	292	267	989001001358541	MGORD	MGORD
9/18/2015	BNT	199	92	989001001952037	MGORD	**Upper Rush**
9/18/2015	BNT	196	74	989001001953466	MGORD	**Upper Rush**
9/18/2015	BNT	259	175	989001001953483	MGORD	**Upper Rush**
9/15/2015	BNT	185	61	989001001231067	Upper Rush	Upper Rush
9/15/2015	BNT	188	68	989001001237249	Upper Rush	Upper Rush
9/15/2015	BNT	169	46	989001001239250	Upper Rush	Upper Rush
9/15/2015	BNT	191	64	989001001239533	Upper Rush	Upper Rush
9/15/2015	BNT	187	66	989001001359844	Upper Rush	Upper Rush
9/15/2015	BNT	203	73	989001001951229	Upper Rush	Upper Rush
9/15/2015	BNT	190	71	989001001951970	Upper Rush	Upper Rush

Appendix B: Table 1. PIT tagged trout recaptured in Rush Creek sections, September 2015.

Date of Recapture	Species	Length (mm)	Weight (g)	PIT Tag Number	Location of 2014 Recapture	Location of Initial Capture and Tagging
9/15/2015	BNT	210	95	989001001951975	Upper Rush	Upper Rush
9/15/2015	BNT	194	75	989001001953400	Upper Rush	Upper Rush
9/15/2015	BNT	174	48	989001001953412	Upper Rush	Upper Rush
9/15/2015	BNT	196	73	989001001953515	Upper Rush	Upper Rush
9/15/2015	BNT	242	128	989001001953780	Upper Rush	Upper Rush
9/15/2015	BNT	208	87	989001001953864	Upper Rush	Upper Rush
9/15/2015	BNT	192	65	989001001953869	Upper Rush	Upper Rush
9/15/2015	BNT	218	105	989001001954071	Upper Rush	Upper Rush
9/15/2015	BNT	206	98	989001001954106	Upper Rush	Upper Rush
9/15/2015	BNT	180	56	989001001954136	Upper Rush	Upper Rush
9/15/2015	BNT	196	72	989001001954146	Upper Rush	Upper Rush
9/15/2015	BNT	182	53	989001001954151	Upper Rush	Upper Rush
9/15/2015	BNT	205	87	989001001954285	Upper Rush	Upper Rush
9/15/2015	BNT	180	56	989001001955056	Upper Rush	Upper Rush
9/15/2015	BNT	190	69	989001001955119	Upper Rush	Upper Rush
9/15/2015	BNT	182	55	989001001955127	Upper Rush	Upper Rush
9/15/2015	BNT	186	40	989001001955140	Upper Rush	Upper Rush
9/15/2015	BNT	213	98	989001001955246	Upper Rush	Upper Rush
9/15/2015	BNT	174	52	989001001955353	Upper Rush	Upper Rush
9/15/2015	BNT	201	77	989001001955577	Upper Rush	Upper Rush
9/15/2015	BNT	202	75	989001001955618	Upper Rush	Upper Rush
9/15/2015	BNT	201	87	989001001955728	Upper Rush	Upper Rush
9/15/2015	BNT	191	67	989001001955743	Upper Rush	Upper Rush
9/22/2015	BNT	182	60	989001001953487	Upper Rush	Upper Rush
9/22/2015	BNT	182	59	989001001953847	Upper Rush	Upper Rush
9/22/2015	BNT	177	53	989001001953896	Upper Rush	Upper Rush
9/22/2015	BNT	227	108	989001001954128	Upper Rush	Upper Rush
9/22/2015	BNT	189	65	989001001954162	Upper Rush	Upper Rush
9/22/2015	BNT	185	59	989001001954335	Upper Rush	Upper Rush
9/19/2015	BNT	249	152	985121021865724	Walker Creek	Walker Creek
9/19/2015	BNT	231	113	985121021886870	Walker Creek	Walker Creek
9/19/2015	BNT	214	95	985121023457153	Walker Creek	Walker Creek
9/19/2015	BNT	211	85	985121023470718	Walker Creek	Walker Creek
9/19/2015	BNT	138	22	989001001231443	Walker Creek	Walker Creek
9/19/2015	BNT	148	31	989001001238297	Walker Creek	Walker Creek
9/19/2015	BNT	177	53	989001001239275	Walker Creek	Walker Creek
9/19/2015	BNT	145	29	989001001354134	Walker Creek	Walker Creek
9/19/2015	BNT	168	41	989001001951239	Walker Creek	Walker Creek

Appendix B: Table 1. PIT tagged trout recaptured in Rush Creek sections, September 2015.

Date of Recapture	Species	Length (mm)	Weight (g)	PIT Tag Number	Location of 2014 Recapture	Location of Initial Capture and Tagging
9/19/2015	BNT	133	20	989001001952005	Walker Creek	Walker Creek
9/19/2015	BNT	150	30	989001001953504	Walker Creek	Walker Creek
9/19/2015	BNT	156	28	989001001953775	Walker Creek	Walker Creek
9/19/2015	BNT	154	33	989001001953849	Walker Creek	Walker Creek
9/19/2015	BNT	151	31	989001001954348	Walker Creek	Walker Creek
9/19/2015	BNT	160	40	989001001955091	Walker Creek	Walker Creek
9/19/2015	BNT	145	27	989001001955581	Walker Creek	Walker Creek
9/19/2015	BNT	167	48	989001001955651	Walker Creek	Walker Creek
9/19/2015	BNT	169	42	989001001955655	Walker Creek	Walker Creek
9/19/2015	BNT	144	30	989001001955684	Walker Creek	Walker Creek
9/19/2015	BNT	156	33	989001001955702	Walker Creek	Walker Creek

Appendix B: Table 2. PIT tagged trout recaptured in Lee Vining Creek, September 2015.

Date of Recapture	Species	Length (mm)	Weight (g)	PIT Tag Number	Location of 2015 Recapture	Location of Initial Capture and Tagging
9/17/2015	BNT	212	89	985121028055967	Main Channel	Main Channel
9/17/2015	BNT	224	104	985121028059034	Main Channel	Main Channel
9/17/2015	BNT	219	94	985121028072873	Main Channel	Main Channel
9/17/2015	BNT	228	130	985121028089243	Main Channel	Main Channel
9/17/2015	BNT	220	96	985121028123337	Main Channel	Main Channel
9/17/2015	BNT	173	47	989001001220283	Main Channel	Main Channel
9/17/2015	BNT	172	45	989001001220652	Main Channel	Main Channel
9/17/2015	BNT	167	43	989001001231194	Main Channel	Main Channel
9/17/2015	BNT	185	57	989001001231222	Main Channel	Main Channel
9/17/2015	BNT	174	43	989001001231269	Main Channel	Main Channel
9/17/2015	BNT	176	54	989001001231634	Main Channel	Main Channel
9/17/2015	BNT	187	60	989001001231704	Main Channel	Main Channel
9/17/2015	BNT	178	57	989001001232519	Main Channel	Main Channel
9/17/2015	BNT	177	50	989001001237627	Main Channel	Main Channel
9/17/2015	BNT	194	79	989001001239982	Main Channel	Main Channel
9/17/2015	BNT	214	80	989001001242188	Main Channel	Main Channel
9/17/2015	BNT	169	45	989001001242613	Main Channel	Main Channel
9/17/2015	BNT	157	33	989001001242901	Main Channel	Main Channel
9/17/2015	BNT	195	74	989001001242965	Main Channel	Main Channel
9/17/2015	BNT	184	58	989001001354225	Main Channel	Main Channel
9/17/2015	BNT	192	64	989001001354231	Main Channel	Main Channel
9/17/2015	BNT	201	79	989001001354731	Main Channel	Main Channel

Appendix B: Table 2. PIT tagged trout recaptured in Lee Vining Creek, September 2015.

Date of Recapture	Species	Length (mm)	Weight (g)	PIT Tag Number	Location of 2014 Recapture	Location of Initial Capture and Tagging
9/17/2015	BNT	186	56	989001001355573	Main Channel	Main Channel
9/17/2015	BNT	196	68	989001001356751	Main Channel	Main Channel
9/17/2015	BNT	207	74	989001001356805	Main Channel	Main Channel
9/17/2015	BNT	201	81	989001001357091	Main Channel	Main Channel
9/17/2015	BNT	203	80	989001001357195	Main Channel	Main Channel
9/17/2015	BNT	211	91	989001001357590	Main Channel	Main Channel
9/17/2015	BNT	190	71	989001001357596	Main Channel	Main Channel
9/17/2015	BNT	201	69	989001001357659	Main Channel	Main Channel
9/17/2015	BNT	210	82	989001001357960	Main Channel	Main Channel
9/17/2015	BNT	153	32	989001001358540	Main Channel	Main Channel
9/17/2015	BNT	183	57	989001001359043	Main Channel	Main Channel
9/17/2015	BNT	213	94	989001001359101	Main Channel	Main Channel
9/17/2015	BNT	193	73	989001001360345	Main Channel	Main Channel
9/17/2015	BNT	152	31	989001001951191	Main Channel	Main Channel
9/17/2015	BNT	157	35	989001001951198	Main Channel	Main Channel
9/17/2015	BNT	170	49	989001001952034	Main Channel	Main Channel
9/17/2015	BNT	158	35	989001001952657	Main Channel	Main Channel
9/17/2015	BNT	161	37	989001001953527	Main Channel	Main Channel
9/17/2015	BNT	149	29	989001001953530	Main Channel	Main Channel
9/17/2015	BNT	175	43	989001001953559	Main Channel	Main Channel
9/17/2015	BNT	151	31	989001001954099	Main Channel	Main Channel
9/17/2015	BNT	159	32	989001001954305	Main Channel	Main Channel
9/17/2015	BNT	167	43	989001001954336	Main Channel	Main Channel
9/17/2015	BNT	194	66	989001001954594	Main Channel	Main Channel
9/17/2015	BNT	172	49	989001001954965	Main Channel	Main Channel
9/17/2015	BNT	179	51	989001001954991	Main Channel	Main Channel
9/17/2015	BNT	168	42	989001001955013	Main Channel	Main Channel
9/17/2015	BNT	167	39	989001001955165	Main Channel	Main Channel
9/17/2015	BNT	156	33	989001001955668	Main Channel	Main Channel
9/17/2015	BNT	167	39	989001001955739	Main Channel	Main Channel
9/17/2015	BNT	178	58	989001004580481	Main Channel	Main Channel
9/24/2015	BNT	188	72	985121027900358	Main Channel	Main Channel
9/24/2015	BNT	150	28	989001001231145	Main Channel	Main Channel
9/24/2015	BNT	164	38	989001001239723	Main Channel	Main Channel
9/24/2015	BNT	156	33	989001001239878	Main Channel	Main Channel
9/24/2015	BNT	192	64	989001001239948	Main Channel	Main Channel
9/24/2015	BNT	162	42	989001001242624	Main Channel	Main Channel
9/24/2015	BNT	172	48	989001001357793	Main Channel	Main Channel

Appendix B: Table 2. PIT tagged trout recaptured in Lee Vining Creek, September 2015.

Date of Recapture	Species	Length (mm)	Weight (g)	PIT Tag Number	Location of 2014 Recapture	Location of Initial Capture and Tagging
9/24/2015	BNT	197	72	989001001358493	Main Channel	Main Channel
9/24/2015	BNT	190	57	989001001358864	Main Channel	Main Channel
9/24/2015	BNT	194	69	989001001359075	Main Channel	Main Channel
9/24/2015	BNT	208	76	989001001359311	Main Channel	Main Channel
9/24/2015	BNT	179	52	989001001953260	Main Channel	Main Channel
9/24/2015	BNT	156	36	989001001954375	Main Channel	Main Channel
9/24/2015	BNT	156	34	989001001954445	Main Channel	Main Channel
9/24/2015	BNT	162	38	989001001954913	Main Channel	Main Channel
9/17/2015	**RBT**	170	50	989001001242191	Main Channel	Main Channel
9/17/2015	**RBT**	204	91	989001001354122	Main Channel	Main Channel
9/17/2015	**RBT**	195	75	989001001355302	Main Channel	Main Channel
9/17/2015	**RBT**	202	79	989001001357801	Main Channel	Main Channel
9/17/2015	**RBT**	216	100	989001001358062	Main Channel	Main Channel
9/17/2015	**RBT**	144	29	989001001954367	Main Channel	Main Channel

Section 4

Monitoring Report
For RY 2015-16

Department of Environmental Science & Management
1 Harpst Street, Arcata, CA 95521-8299

March 16, 2016

Humboldt State University River Institute RY2015 Monitoring Report

Principal Investigator: William J. Trush

Introduction

The Synthesis Report (McBain & Trush and Ross Taylor and Associates 2010) targeted key ecological processes in recommending the Stream Ecosystem Flows (SEFs) guided by the principle of *promoting an ecologically sustainable restoration program and to make ecologically defensible recommendations* (p.129). Aldo Leopold stated this guiding principle better. His essay titled *Conservation: In Whole or in Part?* (1944) concludes: "*Conservation is a state of health in the land. The land consists of soil, water, plants, and animals, but health is more than a sufficiency of these components. It is a state of vigorous self-renewal in each of them, and in all collectively. Such collective functioning of interdependent parts for the maintenance of the whole is characteristic of an organism. In this sense land is an organism, and conservation deals with its functional integrity, or health.*" The program's overall restoration goal, therefore, is restoring the Mono Basin ecosystem's capacity for self-renewal.

As noted in Section 7.1 of the Synthesis Report (p. 124), *the primary impetus on Rush and Lee Vining creeks will be continued monitoring of selected desired ecological outcomes*. Fieldwork in RY2015 was tasked with concentrating on two desired ecological outcomes: (1) preparing a monitoring baseline for documenting and evaluating an evolving, complex channel morphology and (2) identifying a simple monitoring methodology for evaluating cottonwood vigor.

Task No.1. Establish Multi-Purpose Mainstem Channel Monitoring Cross-Sections in Rush Creek Bottomlands

Introduction

Primary expectations for successful Rush Creek and Lee Vining Creek recovery are: (1) narrower channel widths, (2) greater physical complexity, and (3) aggrading floodplains (McBain & Trush and Ross Taylor and Associates 2010). Documenting these physical responses requires monitoring a network of channel cross-sections that target these anticipated long-term responses. Fieldwork in RY2015 focused on establishing a network of mainstem cross-sections in the Rush Creek Bottomlands. In addition to cross-section surveying, the fieldwork provided an opportunity to observe recent mainstem channel down-cutting and the effects of recent beaver activities on channel morphology and shallow groundwater dynamics. Both will strongly influence stream ecosystem recovery, but neither are cleanly amendable to monitoring via stationary cross-sections. Strategic placement of the 10 mainstem cross-sections, requiring as much, or more, effort than the actual surveying, incorporated knickpoint migration at key side-channel entrances.

Rush Creek Bottomlands Cross-Section Survey Descriptions

From August 4th through August 8th 2015, mainstem and side-channel cross-sections were surveyed in the Rush Creek Bottomlands as part of an ongoing monitoring program (Figure 1). The goal of this stream channel cross-section network is to broadly document changes in channel morphology with time including specifically: (1) changes in riffle crest orientation and elevation, (2) knickpoint evolution and movement, (3) side-channel invert elevation relative to the mainstem thalweg, (4) hydraulic roughness, and (5) floodplain aggradation. Aerial photography also will be used in future monitoring to document/measure changes in the mainstem channel's planform shape (e.g., channel bend curvature and meander wavelengths). All cross-sections surveyed during summer RY2015 were located in the lower Rush Creek Bottomlands (from the upstream border of the RB 4-Floodplain down to the Rush Creek Ford). Barrett Penton and Rick Reny, seniors in the HSU Environmental Resource Engineering Department, were the surveying crew after training during the spring in Arcata. Surveying began at a Left Bank Pin, establishing a benchmark (BM) (using an engineer's level surveyed to 0.01 ft accuracy) with an arbitrarily-set elevation of 100.00 ft. Each 'Station' refers to the distance traversed along the cross-section in feet. Each cross-section with fieldnotes was entered into a master Excel file.

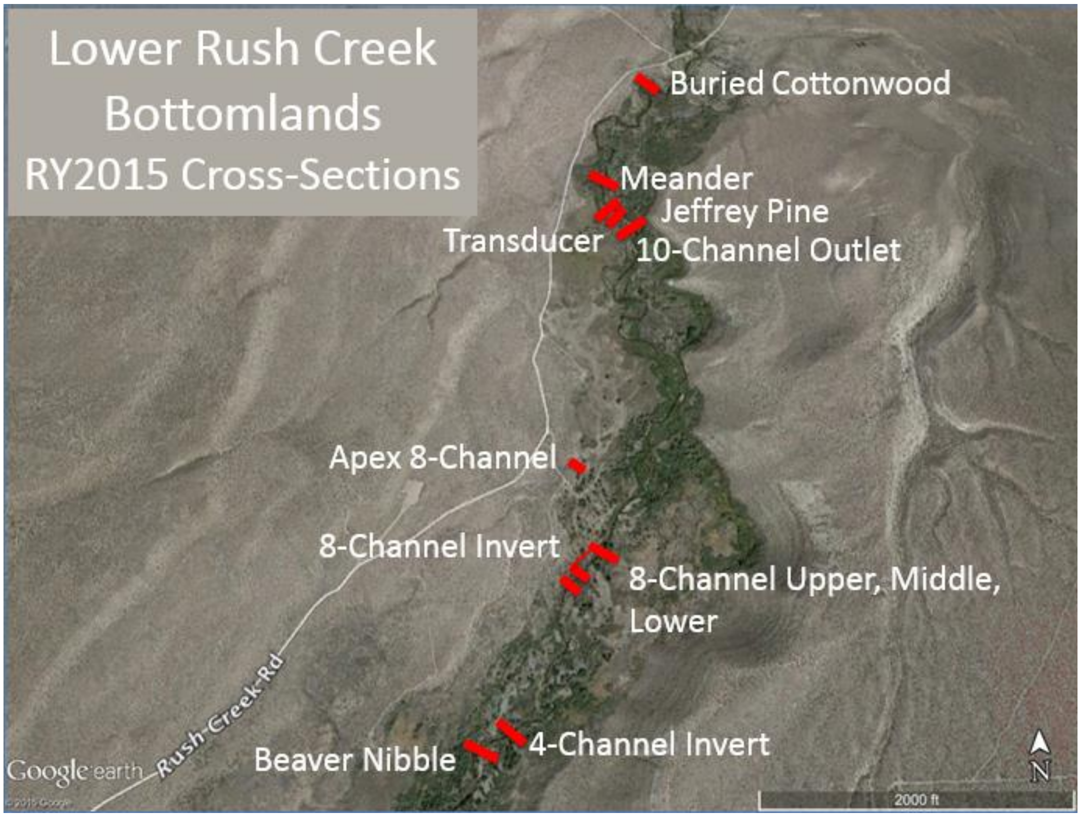


Figure 1. Mainstem and side-channel cross sections surveyed in the Rush Creek Bottomlands in RY2015.

The ten surveyed mainstem cross-sections belonged to one of these four regions of the Rush Creek Bottomlands: (1) 4-Floodplain, (2) Upper 8-Floodplain, (3) 14-Floodplain, and (4) Upper Ford.

4-Floodplain Region of Rush Creek Bottomlands

The most upstream mainstem cross-section was surveyed at the upper side-channel entrance to the right bank 4-Floodplain (Figure 2). A mainstem channel knickpoint has been advancing upstream and functionally disconnecting multiple side-channel inverts to the 4-Floodplain.

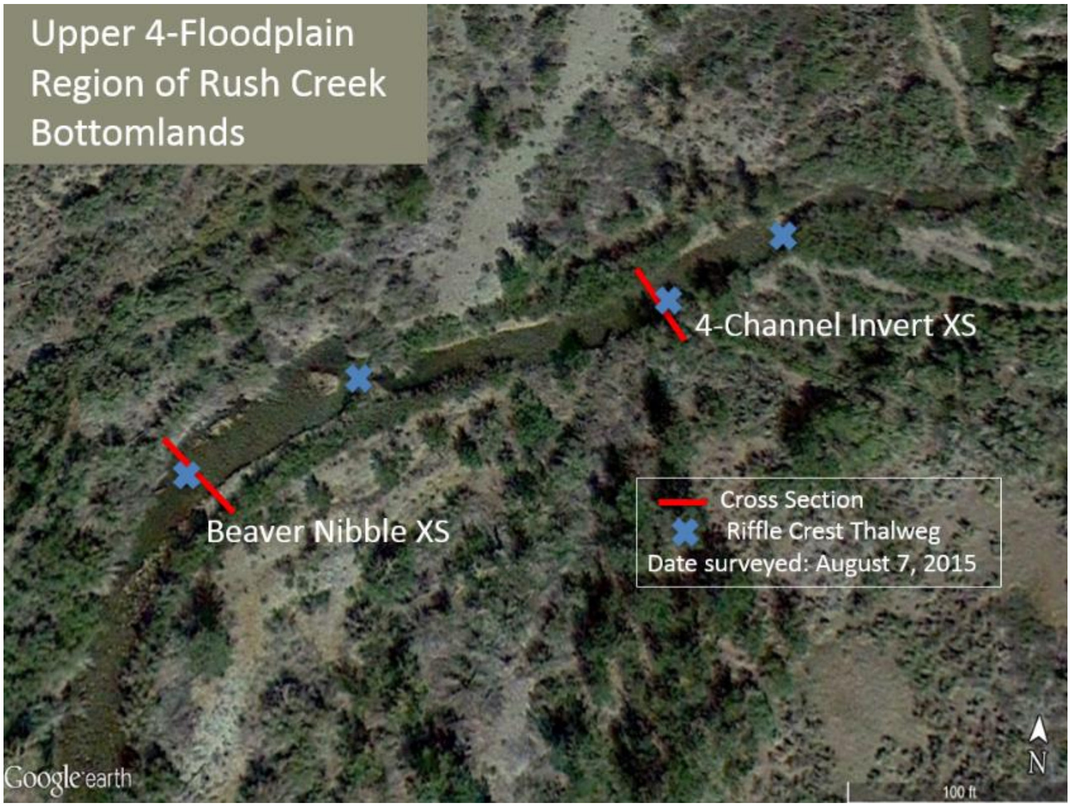


Figure 2. Cross-sections and riffle crest thalweg locations near upper 4 Side-Channel entrance.

Beaver Nibble Cross-Section

The 45.6 ft long Beaver Nibble Cross-Section is the farthest upstream cross-section surveyed in RY2015 (Figure 2), named for its busy beaver activity on the nearby RB floodplain. Its primary monitoring functions are to: (1) document when/if upstream knickpoint migration arrives and (2) chart future changes in channelbed roughness and active channel narrowing.

The Left Bank Pin (Elevation = 100.00 ft) was established through a line of white willows (diameter (D) = 0.5 to 2", height (H) = 8 to 12 ft) with the cross-section intersecting a small gravelbar. The wetted LB channel edge was at Station 3.6 ft (water surface elevation (WSE) = 97.85 ft). A notable elodea mat was growing from Stations 4.2 to 6.0 ft. The main channel's wetted right bank was at Station 29.6 ft (WSE = 97.80 ft). Woody debris from a previous flood event was located on the right bank at Station 42.8 ft (Elevation = 99.11 ft). A Right Bank Pin was established at Station 45.6 ft (Elevation = 99.36 ft), on the edge of a red willow line (D = 0.5 to 4" and Height = 7 to 20'). A riffle crest thalweg was surveyed 1.3 ft upstream of Station 17.4 ft. A capped rebar pin from a previous survey was located at the riffle crest thalweg flush with the channelbed (Elevation = 97.29 ft).

4-Channel Entrance Cross-Section

The 4-Channel Entrance Cross-Section was located 250 ft downstream of the Beaver Nibble Cross Section with a total width of 38.4 ft (Figure 2). The Left Bank Pin (Elevation = 100.00 ft) was established within a line of white willows (D = 2” and H = 15 to 25 ft). Flood debris was documented 1.2 ft downstream from Station 2.9 ft. The left bank wetted edge was at Station 4.8 ft (WSE = 98.02 ft) and the wetted right bank edge was at Station 32.6 ft (WSE = 98.02). The Right Bank Pin, established at Station 38.4 ft (Elevation = 99.45 ft), was located near a cottonwood stand. A riffle crest 3.5 feet downstream of Station 23.0 ft was marked with a capped rebar pin flush with the channelbed (Elevation = 96.55 ft.). The WSE surveyed 100 ft downstream of the 4-Channel entrance, at another riffle crest, was 2.5 ft lower than the WSE at the 4-Channel entrance, identifying a distinctive knickpoint.

Upper 8-Floodplain Region of Rush Creek Bottomlands

The Upper 8-Floodplain Region was surveyed in three locations on mainstem Rush Creek: Upper Riffle, Middle Riffle, and Lower Riffle cross-sections (Figure 3). A fourth cross-section was surveyed on the left bank, just downstream of the Middle Riffle cross-section, where the 8 Side-Channel hydraulically accesses the surrounding 8-Floodplain during higher flows. Surveys of the Middle Riffle and 8 Side-Channel Invert cross section both originated from the same Left Bank Pin (Elevation = 95.79 ft), which was found by tying into an existing pin located on top of the bank separating the main channel from the invert channel (Elevation = 100.00 ft).

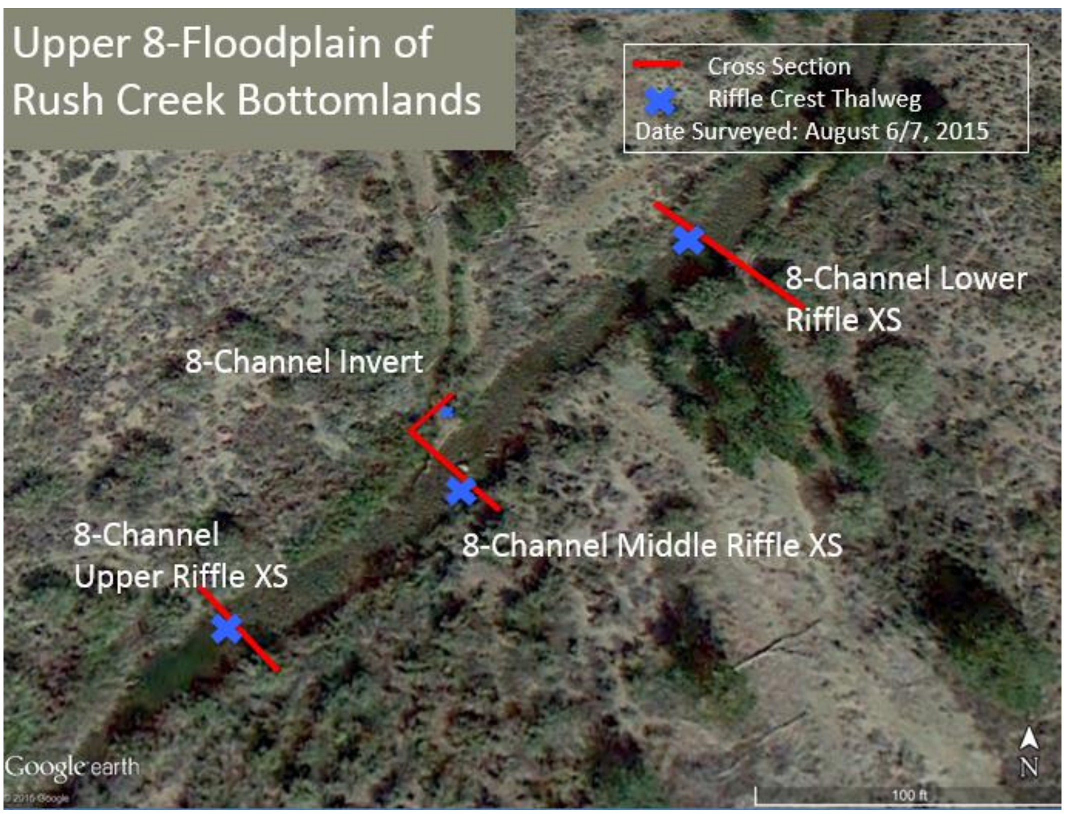


Figure 3. Location of four surveyed cross-sections in Upper 8-Floodplain Region.

8-Channel Upper Riffle Cross-Section

The Upper Riffle cross-section was established 100 ft upstream of the 8 Side-Channel entrance (Figure 3). The Left Bank Pin was established on the left bank floodplain (Elevation = 100 ft), and a total length of 43.8 ft. At Station 10.2 ft, the WSE at the wetted LB edge was 94.77 ft. An existing pin was located 1 ft downstream of the cross-section along the left bank. The wetted RB channel edge at Station 35.8 ft and WSE = 94.77 ft. The Right Bank Pin was established at Station 43.8 ft concealed within a stand of white willows (D = 0.25-2" and H = 10') at an elevation of 96.40 ft. A riffle crest thalweg, 0.5 ft upstream from Station 14.4 ft, was monumented with a capped rebar pin set flush with the channelbed (Elevation = 93.62 ft).

8-Channel Middle Riffle Cross-Section

The 8-Channel Middle Riffle cross-section was established immediately upstream of the 8-Channel Invert spanning a total width of 39.0 ft (Figure 3). The Left Bank Pin was established beneath a white willow (Elevation = 95.79 ft). A deep scour hole was identified behind a notable flood deposit 14 ft farther downstream of the Left Bank Pin. The left bank water edge was at Station 13.9 ft (WSE = 93.64 ft). Two large boulders have been placed in the mainstem at the cross-section location. The smaller boulder was located 6 ft downstream of Station 22.5 ft and the larger boulder was located 4.42 ft downstream of the cross-section between Station 24.2 ft and Station 29.1 ft. The right bank water edge was at Station 37.2 ft with WSE = 93.73 ft. There was an observable difference between the LB and RB wetted edges. The large boulder was forcing the streamflow toward the right bank. The right bank was approximately 10 ft tall with a very steep slope to the 4-Floodplain's surface. The Right Bank Pin was established at Station 39.0 ft (Elevation = 96.35 ft) approximately halfway up the steep floodplain bank. A riffle crest thalweg, located 18 ft downstream of the 8-Channel Middle Riffle cross-section, was monumented with a capped rebar pin flush with the channelbed (Elevation = 92.76 ft).

8-Channel Lower Riffle Cross-Section

The 8-Channel Lower Riffle cross-section was established 200 ft downstream of the 8-Channel entrance (Figure 3). The Left Bank Pin (Elevation = 100.00 ft) was placed on top of the left bank floodplain surface between two willows surrounded by wood rose. The cross-section extended 58.5 ft., bisecting a line of willows (D = 0.5 to 3" and H = 8 to 12') from Station 4.0 ft to Station 9.0 ft before encountering the wetted LB edge at Station 9.1 ft with WSE = 96.45 ft. The wetted right bank edge was at Station 39.5 ft with WSE = 96.41 ft. On the right bank beginning at the wetted edge, a line of willows continued to Station 49.7 ft. There was a gap through the willow line that continued 12.3 ft upstream and 4.5 ft downstream of the cross-section. From Station 39.5 ft to 45.0 ft, cottonwood seedlings (n = 11) were present within 5 ft of the cross-section. The Right Bank Pin was established at Station 58.5 ft, 6 ft behind the right bank under a 3" diameter white willow (Elevation = 98.56 ft). A riffle crest thalweg, located at Station 18.0 ft, was monumented with a capped rebar pin flush to the channelbed (Elevation = 95.63 ft).

8-Channel Invert Cross-Section

This short cross-section spanned the 8 Side-Channel entrance (Figure 3). There was no surface flow at the time of survey, but there was evidence of recent 0.1 ft to 0.3 ft deep surface flows down the 8 Side-Channel that may have reached (before going sub-subsurface) as far downstream as the parking area. The Left Bank Pin was shared with the 8-Channel Middle Riffle cross-section at an elevation of 95.79 ft and extended 18.1 ft to the Right Bank Pin (Elevation = 95.46 ft). An existing pin, 0.35 ft downstream of Station 2.7 ft, was likely used to identify the 8 Side-Channel's invert elevation in previous seasons.

Apex 8-Channel Cross Section

An additional cross-section was surveyed near the apex of the 8 Side-Channel to document recent establishment of extensive cottonwood runners encroaching onto the channelbed (Figure 4). The 57.3 ft wide cross-section had 2-yr and 3-yr old cottonwood runners between Stations 25.0 and 32.0 ft. There was no evidence of recent surface flows, even though 150 ft upstream there was evidence of approximately 0.05 ft deep surface flow.

Figure 4. Apex of 8-Channel curvature with Apex 8-Channel Cross Section.

14-Floodplain Region of Rush Creek Bottomlands

Four cross-sections were surveyed downstream of the 10-Channel outlet and within the RB 14-Floodplain over a 450 ft reach of mainstem Rush Creek (Figure 5). The uppermost cross-section was the 10-Channel Outlet, followed by the Transducer and then Jeffery Pine cross-sections. The Meander cross-section, the farthest downstream, was located on a prominent RB point bar.

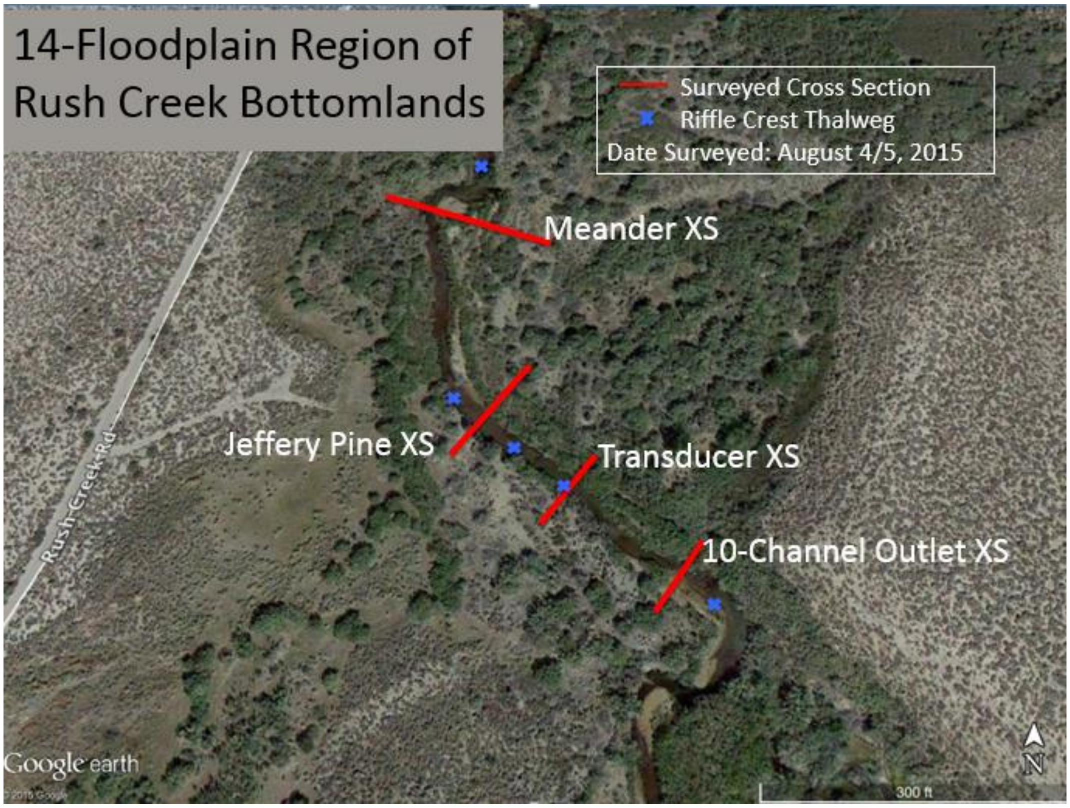


Figure 5. Location of four channel cross-sections surveyed August 4 and 5, 2015 downstream of the 10 Side-Channel confluence with mainstem Rush Creek in the upper 14-Floodplain region of the Rush Creek Bottomlands.

10-Channel Outlet Cross-Section

The 10-Channel Outlet cross-section (Figure 6) is located just downstream of the 10 Side-Channel outlet and 14 Side-Channel inlet along the right bank of the 14-Floodplain (Figure 5). The creek bends river-left through the cross-section, creating an undercut along the right bank. The Left Bank Pin was established under a willow tree and served as the benchmark (Station 0.00 ft and Elevation = 100.00 ft). Small-to-medium sized white willows (D = 1 to 3" and H = 10 to 12 ft) were intersected from Stations 7.5 to 17 ft. A distinct flood debris line was at Station 21.3 ft, where a large Jeffrey pinecone with other woody debris had been deposited recently. The wetted edge of the left bank was at Station 46.2 ft (WSE = 96.53 ft). A submerged sandbar had developed near the left bank between Stations 50.0 to 54.0 ft with two willow saplings attempting to establish in the point bar (D = 0.5"). The Right Bank Pin was located at Station

84.8 ft on the right bank 14-Floodplain surface (Elevation = 101.35 ft). A riffle crest thalweg, 1.2 ft upstream of Station 67.2 ft, had an elevation flush with the channelbed of 95.71 ft. The creek narrows and velocities increase as flow shifts toward the right bank. The change in water surface elevation between the 10-Channel Outlet cross-section and the Transducer cross-section downstream was 1.5 ft, signifying a significant knickpoint.

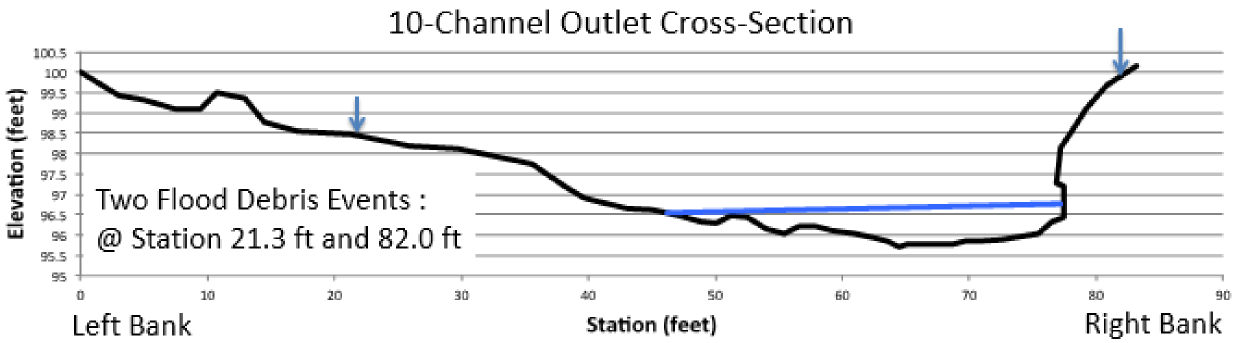


Figure 6. Mainstem channel cross-section for 10-Channel Outlet Cross-Section with (1) an undercut river-right bank (Stations 76.5 ft 77.5 ft) and (2) out-sloped water surface elevation.

Transducer Cross-Section

The Transducer cross-section is located 175 ft downstream of the 10-Channel Outlet cross-section (Figure 5). The Left Bank Pin was established next to a gage plate from a discontinued gaging station (Station 0.0, Elevation = 100.00 ft.). A gaging station housing was located 5.7 ft upstream from the Left Bank Pin. The left bank wetted edge was at Station 8.1 (WSE = 96.2 ft). An elodea mat extended out to Station 16.0 ft. The RB wetted main channel was at Station 32.1 ft. The Right Bank Pin was placed on top the floodplain’s berm, 5.4 ft upstream of a large white willow (Elevation = 97.65 ft). The riffle crest’s thalweg was monumented with a yellow-capped rebar pin flush with the streambed (Figure 7).

Figure 7. Typical yellow-capped rebar pin installed flush with the channelbed at riffle crest thalweg on Transducer cross-section.

Jeffery Pine Cross-Section

The Jeffery Pine cross-section is located 100 ft downstream of the Transducer cross-section (Figure 5). The cross-section bisects the last two Jeffery Pines on the left bank terrace. An existing benchmark pin was located just upstream of the cross-section under a large white willow and was chosen as the Left Bank Pin (Station 0.0 and Elevation = 100.00 ft). The top of the left bank terrace was at Station 39.5 ft before dropping into the mainstem channel. Rush Creek streamflows have undercut the left bank (WSE = 95.67 ft). The main channel extended 26.4 ft, where the wetted edge of the right channel (at Station 65.9 ft) was WSE = 95.59 ft. A former pin was located at Station 94.9 ft that was once used as the Right Bank Pin in previous seasons. The cross-section was extended past the previous pin to gather more information on the surrounding floodplain for monitoring future fine-sediment deposition. A scour hole had developed downstream of a dead white willow at Station 104.2 ft with woody debris deposited during a flood event. From Station 111.0 ft to Station 115.0 ft the scour hole deepens, located between two white willows (one dead, one alive). The new Right Bank Pin was established at Station 119.4 ft, 6.9 ft downstream from a large white willow on the RB floodplain's berm (Elevation = 99.37 ft). Two riffle crest thalwegs were present near the *Jeffery Pine* cross-section, one upstream and the other downstream (Figure 5). Each was monumented with a capped rebar pin flush with the channelbed.

Meander Cross-Section

The Meander cross-section is located 225 ft downstream from the Jeffery Pine cross-section (Figure 5). The main channel makes a considerable right turn through the Meander cross-section, creating an undercut in the left bank. The left end pin is located 21 ft downstream of a large, dead, isolated tree (Station 0.0 ft, Elevation = 100.00 ft). A large scour hole from a previous flood event was present 14 ft downstream of the left end pin, with its deepest elevation of 96.72 ft. A significant quantity of flood debris was present on the left bank from the left end pin to Station 10.5 ft. The left bank wetted edge was at Station 32.0 ft (WSE = 95.98 ft). An elodea mat blanketed the main channel from Station 40.5 ft to Station 42.3 ft. The right bank wetted edge was at Station 50.6 ft (WSE = 95.92 ft). A row of red and white willow saplings was established along the right bank from Station 65.0 ft to Station 70.3 ft (D = <0.5"). Woody flood debris was caught in a red willow 11.6 ft upstream of Station 78.5 ft. Another willow line, from Station 96.0 ft to Station 109.0 ft, consisted of white willows with a few red willows (D = 0.25"to 1.5"and H = 8 to 10'). Most white willows had new growth, with larger dead limbs located towards the interior of the line (D = 2" and H = 8 to 12'). A sandy flood overflow channel was apparent from Station 96.0 to Station 102.3 ft. A new line of white willows has begun at Station 124 ft, with a mix of dead (D = 2-3" and H = 8 to 12 ft) and live (D = 1 to 2" and H = 6 to 10 ft) trees, continuing to Station 129 ft. At Station 139.2 ft, another willow line consisted of mostly white willow up to 12 ft tall. There was a mix of dead and healthy branches, with dead stocks (D= 1 to 2") considerably larger than the newer growth (D = 0.25 to 1.5" and H = 6 to 10 ft). Flood debris had been deposited 1 ft upstream of the cross-section from Station 147.4 ft to Station 151.9 ft. The sandy channel ended at Station 155.0 ft where a new willow line was growing with wood rose. Size and height differed considerably from the willows growing upstream of the cross-section and those growing downstream. Upstream of the cross-section, willows were approximately 15 ft tall, whereas the willows growing downstream of the cross-section were only 7 to 10 ft tall with branch diameters of 0.25 to 1”. The Right Bank Pin was established on top of the right bank floodplain bank at Station 161.0 (Elevation = 100.92 ft). A large flood scour hole was surveyed 7.3 ft past the right end pin at Station 168.3 ft, just downstream of an extensive willow line (D = 2 to 4” and H = 15 to 25’).

Upper Ford Region of Rush Creek Bottomlands

Buried Cottonwood Cross-Section

The Buried Cottonwood cross-section was the lowermost mainstem channel surveyed in August 2015, upstream of a large Fremont cottonwood partially buried by earlier floods (Figure 8). This cross-section was oriented across a riffle crest at the mainstem apex of a river-right point bar.

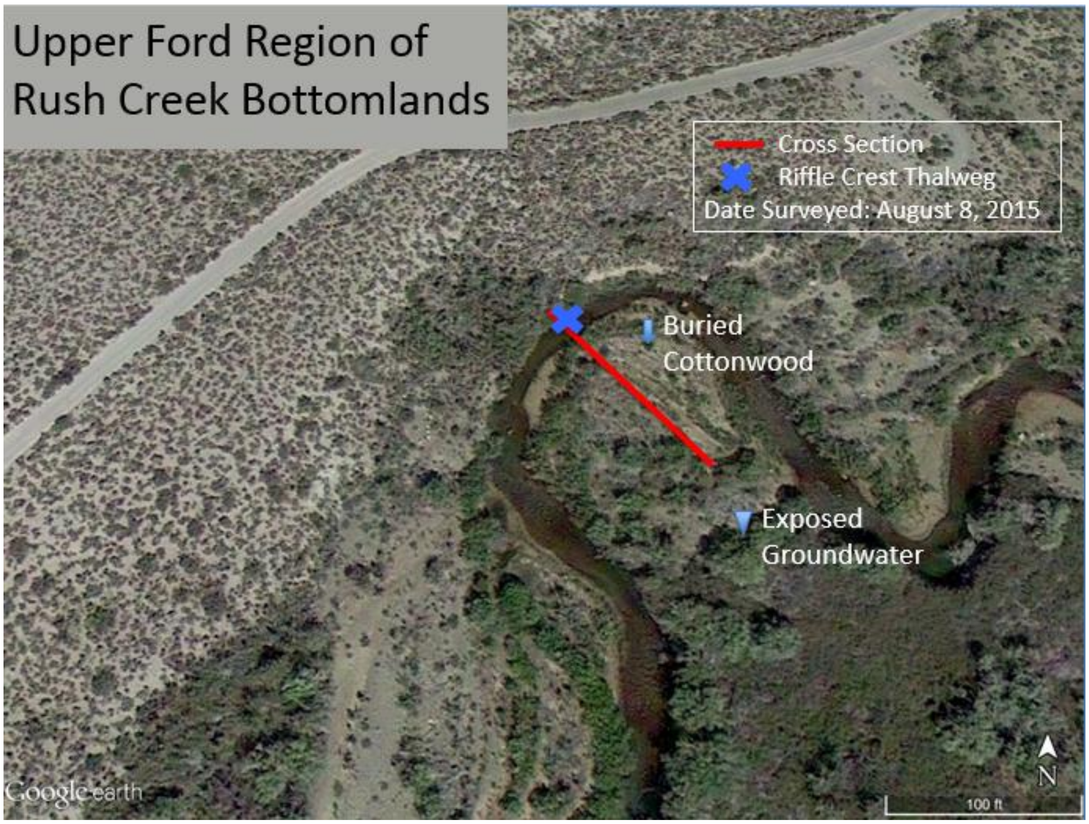


Figure 8. Lowermost channel cross-section surveyed in August 2015 upstream of the Rush Creek Ford (the oval turnout just before dropping into the Ford visible in upper right corner).

A capped rebar pin was established as the Left Bank Pin on the steep bank between the main channel and a large dead willow (Station 0.0 ft, BM = 100.00 ft). The left bank water’s edge was at Station 3.0 ft with a WSE of 97.25 ft. The main channel wetted edge was at Station 23.3 ft with a right bank WSE of 97.26 ft. The right bank is a broad floodplain with an abandoned channel running along its scarp. At Station 25.3 ft, a prominent line of willow saplings has established. Another line of 10 to 15 ft tall white and red willows was established between

Stations 28.7 and 32.8 ft. Flood overflow channels occupied Stations 40.6 to 54.4 ft. A cottonwood sapling (at Station 99.0 ft) originated as a runner from the nearby mature tree. A capped rebar pin was established under a notable line of mostly white willows (H = 10 to 15 ft) and used as the Right Bank Pin (Elevation = 99.62 ft).

RY2016 Fieldwork

RY2016 will be a busy field season completing the following tasks: (1) survey 3 to 5 cross-sections on Lower Lee Vining Creek, (2) establish riffle crest thalweg elevations at, and above/below, entrances to Lee Vining Creek's A4 and B1 Connector side-channels to monument future mainstem down-cutting, (3) re-visiting the Rush Creek Bottomland cross-sections to estimate channel slope at a bankfull discharge (approximately 350 cfs) and greater (for back-calculating Manning roughness coefficient (n)), (4) installing a gage plate on the backside of the 4-Floodplain and measuring groundwater elevation in selected piezometers on the 8-Floodplain, and (5) re-shooting photographs at 10 mainstem locations in lower Rush Creek and 5 mainstem locations in lower Lee Vining Creek.

Task No.2. Explore Technique for Monitoring Fremont Cottonwood Annual Branch Increment (ABI) in the Rush Creek Bottomlands

Introduction

Fremont cottonwoods (*Populus fremontii*) are ideal trees for measuring stress attributable to water availability (Rood et al. 2003; Singer et al. 2012). Kozlowski (1993) states: *In other [freely growing] species, such as poplars and birches, some of the winter buds contain some shoots that are only partially formed (others are fully formed). In such species, leaves preformed in the bud one year expand the next year, but new leaves also form and expand as a stem or branch elongates. Height growth and elongation of branches usually take much longer in species with free growth than in species with fixed growth. Species with free growth will respond to stresses such as drought differently than species with fixed growth. A drought in August would be likely to decrease that year's growth*. Given their major ecological roles in recovering Rush and Lee Vining creek's stream ecosystem, annual cottonwood growth response would be a necessary diagnostic measure for tracking long-term recovery.

Annual branch increment (ABI) is the length (mm) between successive terminal bud scars (Horton et al. 2001; Willms et al. 1998). Beginning at a branch's outer tip, each successive increment backwards, i.e., toward the trunk, counts as one RY's branch growth (Figure 9). Therefore, errors in identifying a terminal bud scar will alter the inter-annual sequence attributable to each RY's branch increment. In RY2015 (the first week in August), cottonwood branches (n = 40, one per tree sampled) were harvested to return to the lab (and stored) for examining each branch closely. In RY2016, ABIs will be measured in the field without harming branches.

Figure 9. Estimation of Fremont cottonwood (*Populus fremontii*) annual branch increments (mm) from RY2010 back to RY2004 (modified from original photograph by John Bair in preparation for McBain and Trush annual monitoring reports).

Cottonwood Growth RY2015 Fieldwork and Findings

In the first week of August 2015, thirty six cottonwoods were sampled (one south-west facing branch per tree) in lower Rush Creek Bottomlands while surveying channel cross-sections. The sampling strategy targeted diverse environmental settings to evaluate how sensitive ABI performed as a practical measure of annual cottonwood growth (vigor). Taking advantage of the recent dry years (RY2014 and R2015), sampled trees ranging from next to the mainstem channel (i.e., reliable water availability) and those trees sampled far from the mainstem channel and substantially higher in elevation than the mainstem channel (i.e., unreliable water availability) would/should revel discernable annual trends in ABI. The greatest ABI measured in RY2015 was 1435 mm for a cottonwood on the bank of the 8-Channel entrance; the shortest was 13 mm for a cottonwood on a terrace the above the 8-Floodplain. An example of one measured cottonwood is provided in Figure 10.

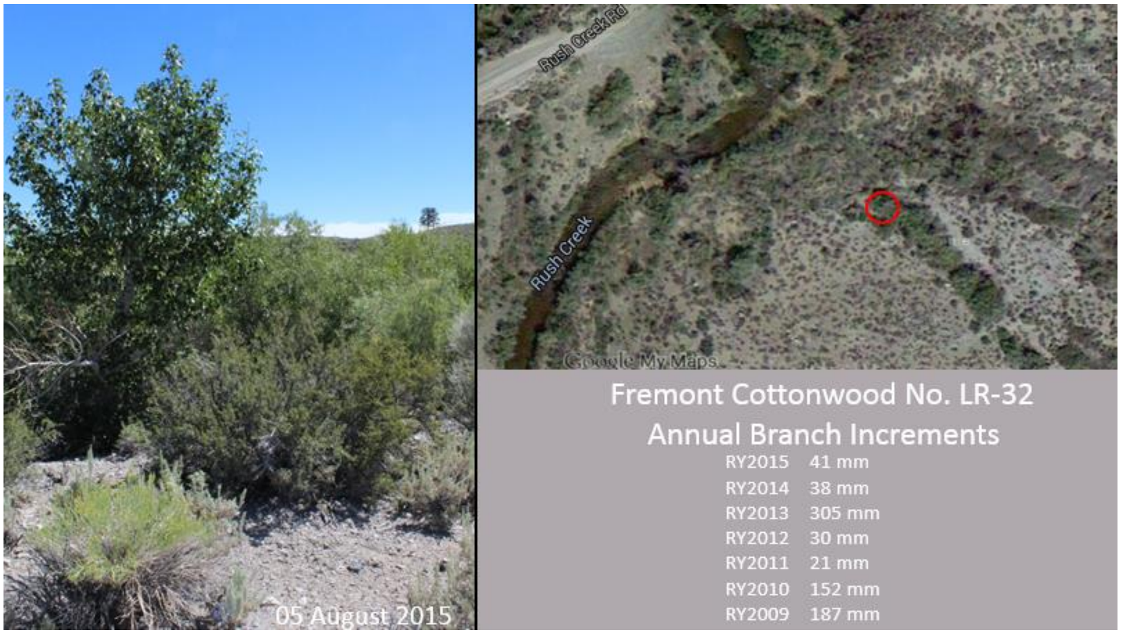


Figure 10. Location and ABIs from RY2015 back to RY2009 for a solitary cottonwood on an abandoned floodplain upstream of the Rush Creek Road Ford.

The cumulative distributions of Fremont cottonwood ABIs exhibited distinctive trends among the eight RYs (Figure 11). Exceedence probability (P-value) on the X-axis was computed by ranking ABIs within each RY, with the greatest increment receiving Rank = 1 and the shortest increment receiving Rank = total sample size measured within a given RY. For example, in RY2012 ABIs ranged from 769 mm to 13 mm with a total sample size of 33 cottonwoods. ABI = 769 mm received a Rank = 1 and ABI = 13 mm received a Rank = 33. Next, the ranks were divided by the total sample + 1 (i.e., in the example, divided by 34) and then multiplied by 100 to produce a cumulative percentage. Figure 11 was generated in this manner for RY2008 up through RY2015. An example helps in understanding how to interpret the P-value in Figure 11. In RY2012, a P-value of 40% meant that 40% of all cottonwoods sampled in the given runoff year had ABIs equal to OR GREATER THAN 100 mm. Using this analytical approach, past and future RY's with varying sample sizes can be readily compared.

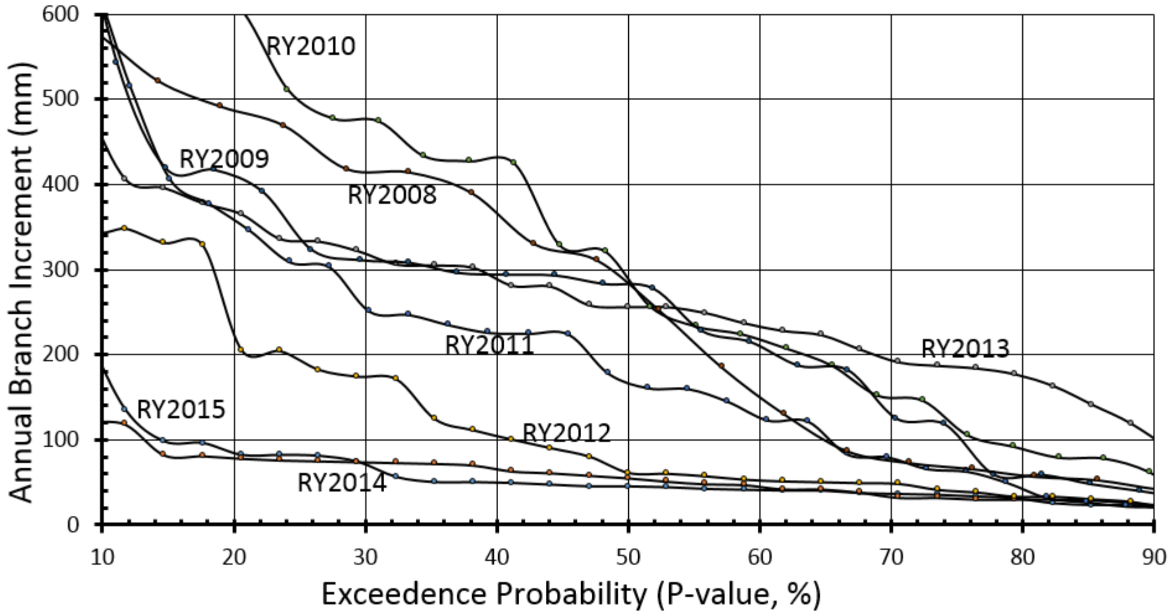


Figure 11. Exceedence probabilities 10% to 90% for Fremont cottonwood annual branch increment (ABI, mm) sampled in RY2015 throughout the Lower Rush Creek Bottomlands. For example (to interpret this figure), approximately 40% of all sampled stems (n = 33) had inter-nodal lengths 100 mm or greater in RY2012.

The wide range in ABI within a given RY partially resulted from sampling strategy. The goal for summer RY2015 was to explore simple monitoring techniques documenting annual cottonwood growth, not evaluate the effect of annual peak releases on cottonwood vigor until the monitoring program is underway. Cottonwoods situated horizontally and vertically close to the mainstem channel would have a more reliable water source through the summer and between RY's. These trees were represented by P-values greater than approximately 40%. In contrast, cottonwoods occupying former floodplains that are hydraulically isolated because of mainstem channel down-cutting, and considerably drier, were represented by P-values exceeding 60%.

The solitary cottonwood on the abandoned floodplain above the Rush Creek Ford in Figure 10 provides an example. ABIs, ranging from 21 mm in RY2011 up to 305 mm in RY2013, had P-values mostly higher than 60% characterizing this cottonwoods relatively dry environment in most RYs (Figure 12). But in RY2013 its ABI was 305 mm with a P-value of 37.5%. RY2013 was a relatively good year, with respect to branch growth, for many trees situated in drier environments (i.e., at P-value = 90% the ABI for RY2013 was 100 mm).

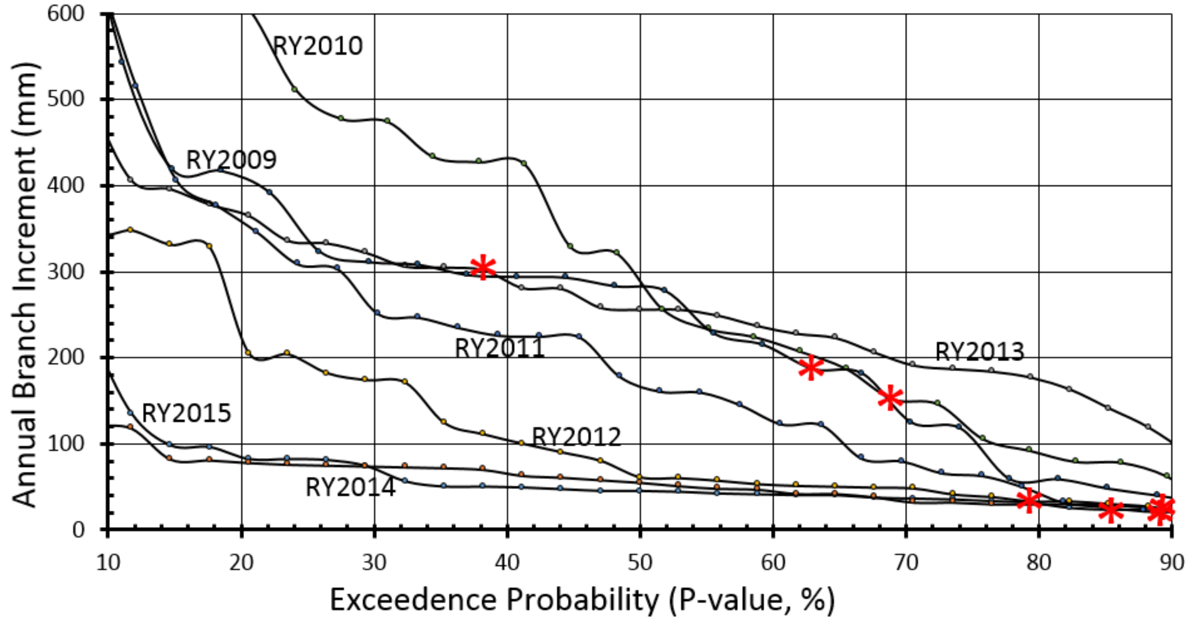


Figure 12. ABI's for a solitary cottonwood (in red asterisks) on the abandoned floodplain above the Rush Creek Ford for RY2015 back to RY2009.

RY2016 Fieldwork

Results from RY2015's ABI measurements were encouraging as a simple, but quantitative measure of annual cottonwood vigor suited to a long-term monitoring plan. Although measuring ABI back to RY2007 or earlier for a given cottonwood branch requires expertise/practice, measuring only the current RY's ABI is considerably more straightforward. By carefully selecting distinctive environmental settings within which to annually measure cottonwoods' ABI annually, the ecological performance of dam releases can be reasonably quantified/assessed without demanding a research project. In summer 2016, the following tasks will be pursued: (1) sample ABIs within cottonwood stands/floodplains/terraces differing in environmental settings primarily with respect to water availability (i.e., RY2016 will be considered first complete sampling season), (2) measure ABIs for recent extensive encroachment by cottonwood runners into the 8 Side-Channel channelbed near the parking area, and (3) explore measuring RY2016 ABIs for white willow (and other species as well) (i.e., going back in time to measure ABI may not be feasible, but measuring future ABIs annually seems highly plausible), especially in lower 4-Floodplain and 14-Floodplain.

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Section 5

Mono Basin Waterfowl Habitat and Population Monitoring 2015-16

Waterfowl Director Statement
Mono Lake Waterfowl Population Monitoring
Mono Lake Limnology Monitoring

Mono Basin Waterfowl Habitat Restoration Monitoring

2015 Mono Lake Compliance Report

In 2015 the Los Angeles Department of Water and Power (LADWP) conducted the following monitoring in compliance with the 1996 Mono Basin Waterfowl Habitat Restoration Plan (Plan) (LADWP 1996) and the reports are contained within:

- Summer waterfowl ground counts, brood surveys and documentation of habitat use
- Fall aerial waterfowl surveys at Mono Lake, Bridgeport Reservoir and Crowley Reservoir
- Still-image photography of waterfowl habitats at Mono Lake, Bridgeport Reservoir and Crowley Reservoir taken from a helicopter
- Lake limnology including meteorological, physical/chemical, phytoplankton, and brine shrimp population monitoring
- Surveillance for saltcedar (*Tamarix* spp.) during summer waterfowl surveys

Summary of Findings

The 2015 runoff year in the Mono Basin (April 1, 2015 - March 31, 2016) was a "dry" year type with 25% of average runoff predicted. This was the fourth consecutive dry year, and the gradual decline in lake elevation that began in spring of 2012 due to ongoing drought continued. Mono Lake dropped a total of 1.1 feet in 2015 to a low of 6378.0 feet by December. In 2015 Mono Lake was at its lowest elevation since 1996 when the Mono Basin Waterfowl Restoration Plan was adopted.

Waterfowl

Over the last four years, the decline in lake elevation has resulted in the gradual drying of many seasonal and semi-permanent ponds used by breeding waterfowl. Conditions for breeding waterfowl in 2015 were not favorable in many lakeshore segments, but stable to improved in others. Summer breeding waterfowl population indices were below the long-term 2002-2015 mean.

Total waterfowl use at Mono Lake in fall was also below the long-term mean. Reduced numbers of Ruddy Ducks contributed significantly to the overall decrease in total fall waterfowl use in 2015. Similar to Mono Lake, total waterfowl use at Bridgeport Reservoir in fall 2015 was also below the long-term mean, with low water levels at Bridgeport potentially contributing to decreased waterfowl numbers. Waterfowl use of

Crowley Reservoir was above the long-term mean. A comparison of the waterfowl use between the three lakes suggests Ruddy Duck declines at Mono Lake were not observed elsewhere and may be a response to conditions at Mono Lake.

Breeding waterfowl populations at Mono Lake show a positive relationship with lake elevation and local conditions. Total fall waterfowl numbers at Mono Lake and Crowley Reservoir are not related to lake elevation when evaluated on a lakewide scale; however additional analysis may reveal changes in spatial distribution in response to lake elevation at other spatial scales. Waterfowl use of Bridgeport has been related to reservoir level.

Limnology

In 2015, Mono Lake experienced holomixis or complete autumnal mixing for the fourth year in a row. Mean adult *Artemia* abundance was 37% lower in 2015 compared to 2014, and peak adult abundance was 47% lower. Long-term parameters indicate a below average seasonal peak in adult *Artemia* and a mean abundance 50% lower than the long term mean. February to early June water column temperatures were warmer as compared to 2014. Secchi depths indicate that Mono Lake was eutrophic and lake transparency did not increase by several meters in summer months as occurred prior to 2014. Reduced lake levels coupled with warm water temperatures and readily available nutrients may be supporting high concentrations of algal biomass. Excess algal biomass can result in self shading and reduce light attenuation throughout the water column inhibiting photosynthesis by plankton in a reduced euphotic zone. Increased senescence of light limited plankton may result in reduced oxygen availability throughout the water column. Although dissolved oxygen levels increased in 2015, biological oxygen demand from vertical mixing may explain continued low summer epilimnetic DO levels compared to historical data. Changes in algal assemblage type and distribution may result in less palatable food items for *Artemia*. Chlorophyll a densities are not useful in evaluating changes in plankton communities therefore any potential changes in specific plankton assemblages are not captured utilizing the current sampling protocol. Sizeable declines in year to year mean adult *Artemia* densities are quite common throughout Mono Lake's monitored history. Less common, are shorter intervals of high adult density during summer months as occurred the past two years.

2015 continues a trend of larger 1st generations with low summer recruitment and rapid late summer/autumn declines.

Recommendations

SWRCB Order WR 98-05 directed LADWP to implement restoration measures in the Plan and conduct monitoring to assess the success of waterfowl habitat restoration efforts. Under the Mono Basin Implementation Plan (LADWP 2000), waterfowl population monitoring in the Mono Basin was to continue until at least the year 2014, or until the targeted lake level (6,392 foot elevation) was reached and the lake cycled through a complete wet/dry cycle. Recovery of lake elevation to the target level is taking much longer than anticipated and predicted by previous models and Mono Lake has not yet reached the targeted lake elevation since implementation of the Plan.

In 2014, a recommendation was put forth that LADWP prepare a synthesis report incorporating monitoring data from all components of the 1996 Waterfowl Restoration Plan: hydrology, lake limnology and secondary producers, vegetation status in riparian and lake-fringing wetland habitat, and waterfowl population surveys and studies. This synthesis report was not completed, however the recommendation still stands. A synthesis of the data collected as part of the Waterfowl Restoration Plan will allow the State Water Resources Control Board, LADWP and interested parties the ability to evaluate the success of waterfowl habitat restoration efforts to date, and the efficiency and efficacy of the program at fulfilling both the requirements and intent of the Plan. Recommendations for modifications to the current program or for management of waterfowl habitat at Mono Lake should be addressed, if warranted.

Debbie House 15 March 2016

Debbie House

Interim Mono Basin Waterfowl Monitoring Program Director

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Los Angeles Department of Water and Power (LADWP). 2000. *Mono Basin Implementation Plan.* To comply with State Water Resources Control Board Decision 1631 and Order No. 98-05 and 98-07.

MONO LAKE WATERFOWL POPULATION MONITORING

2015 Annual Report

Prepared by: Debbie House
Watershed Resources Specialist
Los Angeles Department of Water and Power

Prepared for:
State Water Resources Control Board

March 2016

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EXECUTIVE SUMMARY

Waterfowl populations were monitored in 2015 at Mono Lake, Bridgeport Reservoir, and Crowley Reservoir, as a component of the 1996 Mono Basin Waterfowl Habitat Restoration Plan. At Mono Lake, three summer ground surveys were conducted documenting species composition, habitat use and brood production. Six fall aerial surveys were conducted at Mono Lake, Bridgeport Reservoir, and Crowley Reservoir, providing an index of waterfowl numbers using each body of water during fall migration. The fall aerial surveys of Bridgeport and Crowley Reservoirs were conducted in order to provide data to determine whether or not long-term trends observed at Mono Lake are mirrored at neighboring Mono County lakes or are specific to Mono Lake.

The 2015 runoff year in the Mono Basin (April 1, 2015 - March 31, 2016) was a “dry” year type with 25% of average runoff predicted. Mono Lake was at its highest level in 2015 in March at 6379.1 feet, and dropped a total of 1.1 feet during the year to a low of 6378.0 feet by December.

The total number of waterfowl summed over the three summer surveys (862) was below the 2002-2015 average. The four species that used the Mono Lake shoreline habitats for brooding were Canada Goose, Gadwall, Green-winged Teal, and Mallard. The number of broods observed in 2015 at Mono Lake (38) was below the 2002-2015 mean. The habitats waterfowl were observed most frequently were ria, brackish ponds, and freshwater ponds.

Fall aerial surveys of Mono Lake recorded a total of 16,882 individuals and eleven waterfowl species. Total waterfowl use at Mono Lake in fall 2015 was below the long-term mean. Northern Shoveler and Ruddy Duck were the dominant species during fall migration with Northern Shoveler accounting for 73% (12,270) of all detections and Ruddy Duck accounting for 20% (3,563) of all detections. The peak one-day count of 8,437 waterfowl occurred on the September 2 survey.

A total of 25,817 individuals and fifteen waterfowl species were recorded at Bridgeport Reservoir during fall aerial surveys. The most abundant species were Northern Shoveler, Gadwall and Canada Goose. On September 17, the peak number of waterfowl detected at Bridgeport Reservoir was 5,434.

A total of 65,133 individuals and sixteen waterfowl species were recorded at Crowley Reservoir during the six fall surveys. The most abundant species were Ruddy Duck, Northern Shoveler, Northern Pintail and Mallard. The peak number detected at Crowley Reservoir was 16,117 and occurred during the October 2 survey.

At the restoration ponds, 65 waterfowl of six species and eight Gadwall broods were observed during summer ground counts. Fall aerial counts recorded 211 waterfowl of seven species.

There is a trend towards increased waterfowl use in summer as a function of increases in Mono Lake elevation. The number of broods at Mono Lake from 2002-2015 has been significantly positively correlated with the lake elevation. There was no correlation between total fall waterfowl numbers and Mono Lake elevation in September. The number of waterfowl using Bridgeport was positively correlated with reservoir level, while at Crowley Reservoir no relationship was observed.

Waterfowl Monitoring Compliance

This report fulfills the Mono Lake waterfowl population survey and study requirement set forth in compliance with the State Water Resources Control Board (SWRCB) Order No. 98-05. The waterfowl monitoring program consists of summer ground counts at Mono Lake, fall migration counts at Mono Lake, fall comparative counts at Bridgeport and Crowley Reservoirs, and photos of waterfowl habitats taken from the air. Three summer ground counts and six fall aerial surveys were conducted at Mono Lake in 2015. Six comparative fall aerial counts were completed at Bridgeport and Crowley Reservoirs. Photos of shoreline habitats were taken from a helicopter on September 22, 2015.

2015 Mono Lake Waterfowl Population Monitoring
Los Angeles Department of Water and Power
Prepared by Debbie House
Watershed Resources Specialist
Bishop, CA

INTRODUCTION

In 1996, the Mono Basin Waterfowl Habitat Restoration Plan (Plan) was prepared by the Los Angeles Department of Water and Power (LADWP) for the State Water Resources Control Board (SWRCB) (LADWP 1996). This plan identified restoration objectives and potential projects in addition to land management efforts designed to mitigate for the loss of waterfowl habitat due to the lowered elevation of Mono Lake. The key components of the Plan are:

a) increasing the water surface elevation of Mono Lake to 6,392 feet,
b) rewatering Mill Creek,
c) rewatering specific distributaries in the Rush Creek bottomlands,
d) implementation of the DeChambeau Pond and County Pond Restoration Project,
e) development and implementation of a prescribed burn program, and
f) control of saltcedar in lake-fringing wetlands.

The item identified as being the restoration measure of highest importance and priority was to increase the water surface elevation of Mono Lake to 6,392 feet.

SWRCB Order WR 98-05 (SWRCB 1998) directed LADWP to implement the above restoration measures in the Plan and conduct monitoring to assess the success of waterfowl habitat restoration efforts. Components of the waterfowl habitat monitoring plan include the monitoring of lake levels, lake limnology and secondary producers, the mapping of riparian and lake-fringing wetland habitats, and waterfowl population surveys. The purpose of the waterfowl population survey component of the Plan is to provide information to track changes in population levels of waterfowl and assess waterfowl use of the various wetland habitats.

This report describes and discusses monitoring efforts related to evaluating waterfowl population responses to increases in Mono Lake water surface elevations. Survey data for the DeChambeau and County Restoration Ponds are also presented.

Summer ground surveys were conducted in order to determine the size of the breeding and/or summering population, species composition, spatial distribution and habitat use of waterfowl during the summer. Aerial surveys were conducted to document waterfowl abundance, species composition and spatial distribution at Mono Lake during fall migration. Fall waterfowl surveys were also conducted at Bridgeport and Crowley Reservoirs in order to provide data to evaluate whether long-term trends observed at Mono Lake are mirrored at neighboring Mono County lakes or are specific to Mono Lake.

All summer surveys were conducted by the author. Fall surveys were conducted by the author with assistance from Mr. Chris Allen, LADWP Watershed Resources Specialist.

DESCRIPTION OF SURVEY AREAS

Under the Mono Basin Waterfowl Restoration Plan, waterfowl surveys were conducted at Mono Lake and two nearby lakes - Bridgeport Reservoir and Crowley Reservoirs in Mono County, California (Figure 1). Just east of the town of Lee Vining, Mono Lake is almost centrally located in Mono County. Bridgeport Reservoir is approximately 36 km northwest of Mono Lake near the town of Bridgeport, while Crowley Reservoir is approximately 50km southeast of Mono Lake, and 20 km southeast of Mammoth Lakes.

Mono Lake

Mono Lake is the largest lake in Mono County with a surface area of approximately 223 km^2. Mono Lake is a terminal saline lake whose waters are more than twice as saline as ocean water. Mono Lake is fed by several perennial streams that originate from the eastern slope of the Sierra Nevada and flow into the west side of the lake, the largest of which are Rush Creek, Lee Vining Creek and Mill Creek. There are also numerous springs located throughout the basin and around the lakeshore that support the growth of wetland vegetation and create additional fresh and brackish water resources for waterfowl.

As a component of the Waterfowl Restoration Plan, lake-fringing vegetation has been mapped approximately every five years. Lake-fringing habitats at Mono Lake include streams, freshwater ponds, brackish ponds and hypersaline ponds, unvegetated (exposed playa or shoreline), wet meadow, alkaline wet meadow, marsh, riparian woodland and scrublands, and upland scrub. A description of the vegetation communities used for the most recent vegetation inventory conducted in 2014 can be found in Appendix 1.

The 2015 runoff year in the Mono Basin (April 1, 2015 - March 31, 2016) was a "dry" year type (see Order WR 98-05) with a predicted runoff of 25% of the 1941-1990 average. A wet spring and summer followed this very dry and warm winter, and above average precipitation was recorded May through July. Precipitation data from the Cain Ranch weather station at the intersections of Highway 395 and north June Lake Junction (Highway 158) recorded 3.33 inches in May 2015 (average = 0.40 inches), 0.91 inches in June (average = 0.38), and 1.36 inches in July (average 0.37). During the 2015 runoff year, Mono Lake was at its highest in elevation in March, and then again in July at 6,379.1 feet, in response to the spring and summer precipitation. The lake level steadily declined throughout the year after July, lowering an additional 1.1 feet to a low of 6378.0 feet in December (http://www.monobasinresearch.org/data/levelmonthly.php). In early summer (June) the lake level was 6379.1 feet, or 1.3 feet lower than it had been during the same time in 2014. The lake level continued to decline through the summer and at the start of fall surveys in September, the elevation was 6378.4 feet, which was 1.2 feet lower than September 2014.

Mono Lake Shoreline Segments

The Mono Lake shoreline was divided into 15 lakeshore segments in order to document the spatial use patterns of waterfowl (Figure 2). The segment boundaries are the same as those used by Jehl (2002), except for minor adjustments made in order to provide the observer with obvious landmarks that are easily seen from the air during fall aerial surveys. Coordinates forming the beginning of each segment were derived from the 2002 aerial photo of Mono Lake (2002 aerial image taken by I. K. Curtis, and processed by Air Photo, USA) and can be found in Appendix 2, along with the four-letter code for each lakeshore segment. Photos taken from a helicopter at all lakes on September 22, 2015 are used below to describe areas surveyed in 2015.

DeChambeau Creek (DECR)

DeChambeau Creek lies along the northwest shore. Flows in DeChambeau Creek are intermittent and do not reach the lakeshore, however freshwater resources are abundant as there are numerous springs in this area (Figure 3). In 2014, the DeChambeau Creek area was dominated by wet meadow, mudflats, and smaller amounts of riparian shrub and marsh. Based on 2014 mapped conditions, approximately half the area is exposed playa. In 2015, wetland vegetation was beginning to colonize areas of exposed playa, especially in the western half where there is significant spring flow.

Mill Creek (MICR)

Mill Creek, Mono Lake's third largest tributary originates in Lundy Canyon. Mill Creek water has never been diverted for export, but creek flows are diverted for hydropower, with return flows diverted to the Wilson Creek drainage. Diverted Mill Creek water has most recently been used by multiple water rights holders, including Mono County, Bureau of Land Management, and private land owners for fish-rearing and irrigation. Historically, water diversions have affected Mill Creek riparian vegetation. Under the Mono Lake Water Right Decision 1631, the State Water Resources Control Board indicated that the allocation of water between Mill Creek and Wilson Creek would be addressed with respect to restoration and protection of Mono Lake resources (SCE 2007). Following several years of negotiations between stakeholders, an amended Federal Energy Regulatory Commission License was issued to Southern California Edison (SCE) in which SCE proposed to install the necessary infrastructure needed to return desired flow to Mill Creek, downstream of the powerhouse (SCE 2011). This work has not been completed due to difficulties in obtaining necessary easements.

Unvegetated streambar areas primarily associated with the abandoned channel of Mill Creek are the most abundant habitat type in this area. In the vicinity of the active channel, riparian shrub, wet meadow, and barren shoreline are the dominant habitat types. In 2015, shoreline retraction seemed less apparent in the Mill Creek delta than other areas. There continues to be extensive beaver activity in the delta, creating additional waterfowl habitat suitable for brooding and feeding (Figure 4)

Wilson Creek (WICR)

Wilson Creek is along the northwest shore. The Wilson Creek area supports the highest proportion of water features of any of the lakeshore segments. Meadow habitats including wet meadow, alkali meadow and rabbitbrush meadow are the dominant vegetation types. Several significant springs also occur in this area, leading to the creation of mudflats at most lake elevations observed.

Significant changes were observed in the Wilson Creek area with the additional drop in lake elevation. The water level had receded to a point at which little remained of the protected bay often present in this area (Figure 5). All of the springs in the Wilson Creek area continued to maintain connectivity with the lake. The small beaver dam near the outflow of Black Point Seep was still present but only limited use of the beaver pond by waterfowl was observed in 2015.

Black Point (BLPO)

Black Point is a volcanic hill on the northwest shore of Mono Lake. Existing alkali and wet meadow vegetation occurs primarily upgradient of the shoreline. Exposed shoreline comprises almost 60% of the area. In 2015, the Black Point shoreline area was dry and appeared to lack notable waterfowl resources (Figure 6).

DeChambeau Embayment (DEEM)

The DeChambeau Embayment area lies just east of the historic DeChambeau Ranch, and the DeChambeau and County Restoration ponds. Historically, conditions in this area may have been influenced by irrigation of DeChambeau Ranch. Vegetation in this area, dominated by alkali and wet meadow, is primarily confined to the inland portions of the embayment. Several small springs flow into the lake in this area, the largest of which is Perseverance Spring (Figure 7). The decrease in lake elevation over the last several years has resulted in the exposure of large expanses of playa and pumice blocks along the western portion of this shoreline area. From Perseverance Spring south, shoreline recession was similar to that observed in Northeast Shore and Bridgeport Creek, and a landbridge had formed between the mainland and the large flat island northwest of Negit Island. In the eastern portion of this shoreline area (along the north shore of Mono Lake) the shoreline expansion was minimal, and although flow from all springs in this part of the shoreline continued to reach the lake, the exposed playa appeared drier than in 2014.

Bridgeport Creek (BRCR)

This shoreline area is at the terminus of the Bridgeport Creek drainage, however there is not surface flow in the creek near the lakeshore. A few small springs exist in this area, but in 2015 these springs did not appear to directly discharge to the lake. Alkali meadow, wet meadow, and barren playa are dominant, while water resources are almost absent (Figure 8). The shoreline in the Bridgeport Creek area had receded over 150 meters as compared to 2014.

Northeast Shore (NESH)

In the Northeast Shore area, groundwater too saline to support vegetation results in extensive areas of barren playa at most lake elevations. Barren playa currently comprises 99% of the Northeast Shore area, with only a small amount alkali meadow present. In the Northeast Shore area, the shoreline receeded an additional 150-200 meters as compared to 2014. In 2015 a narrow band of water was present along much of the length of the Northeast Shore where presumably groundwater was seeping up at the change in slope (Figure 9).

Warm Springs (WASP)

The Warm Springs area is located on the eastern shore of Mono Lake. The main feature of the Warm Springs area is the permanent brackish pond that is fed by the outflow of Pebble and Twin Warm Springs (referred to as “north pond”) (Figure 10). These and other springs in the area support extensive wet meadow, alkali meadow and marsh vegetation, primarily around the pond and springheads. Late spring and early summer rains resulted in extensive flooding of many depressions in the Warm Springs area and good waterfowl habitat conditions in early summer. By July, the areas filled by spring rains had dried, however the permanent brackish pond continued to provide waterfowl habitat. The exposed playa at Warm Springs was essentially dry with the exception of a small seasonal brackish water area downgradient of the north pond. Other spring channels in the Warm Springs area that are typically quite wet appeared drier than usual by July. Four new springs surfaced in the exposed playa of Warm Springs area in 2015 (from north to south: Slow Seep, Bison Spring, Sanderling Spring and Sandhill Spring). “Wolf Spider Spring”, discovered in 2014 was still flowing.

Sammann’s Spring (SASP)

The Sammann’s Spring area includes the southeastern portion of the lakeshore. There are numerous springs in the Sammann’s Springs area, supporting large amounts of wet meadow and marsh. There are several small ephemeral to permanent ponds in the area, and the shoreline waterfowl habitat appears to change readily with lake elevation changes. In the Sammann’s Spring area, the decline in lake elevation resulted in additional expansion of unvegetated shoreline. Due to incision as a result of downcutting in response to the drop in lake level, spring flow remained confined to narrow channels within the exposed playa in most of the Sammann’s Spring area. As a result, much of the exposed shoreline was dry, except in the vicinity of Terminal and Abalos Springs, where incision had not taken place. The broad area of exposed playa that existed at Sammann’s Springs in 2015 created a condition in which productive feeding areas on shore were far from nesting habitat (Figure 11). In addition, west of Sammann's Spring faultline, emergent vegetation encroaching on shallow fresh water ponds have decreased the available open water habitat in this area. Permanent to semi-permanent brackish water sources were present through the year just east of the Sammann's Spring faultline (Figure 12), however, the remainder of the Sammann's Springs shoreline to the east was dry.

South Shore Lagoons (SSLA)

The South Shore Lagoons area includes areas of permanent freshwater ponds supported by springs, and seasonal to semi-permanent ponds supported by groundwater that develop with increases in lake elevation. The shoreline in this area is affected by longshore currents transporting sands, forming littoral bars, resulting in the redirection of water resources. Dominant community types include wet meadow, rabbitbrush scrub, eolian deposits, and marsh. Habitat conditions appeared very good for breeding waterfowl around Goose Springs in the eastern South Shore Lagoons area (Figure 13). A large freshwater pond had formed as direct flow from Goose Springs to the lake was intercepted by the formation of a large berm. This large pond remained hydrologically connected through small channels to several smaller ponds closer to the springheads, but hydrologically disconnected from the lake.

Sand Flat Spring continued to provide a small amount of open water habitat for waterfowl (Figure 14). Sand Flat Spring supports two small permanent fresh water ponds at the spring source. Fresh water continues to seep through the loose sand downgradient of the ponds, creating very shallow freshwater areas onshore. Due to the decreased lake elevation, the westernmost semi-permanent brackish pond remained dry in 2015, however the shallow brackish pond that developed in 2014 downgradient and immediately onshore, persisted (Figure 15). All other ephemeral, seasonal, and semi-permanent ponds in the South Shore Lagoons area were dry.

South Tufa (SOTU)

The South Tufa area is the primary visitor access point to the Mono Lake shoreline and includes a large display of tufa towers. Rabbitbrush scrub, upland scrub, and wet meadow are abundant. Ephemeral to semi-permanent ponds are common in the eastern portion of this area near Navy Beach in some years. In the South Tufa area (Figure 16), the gradual decrease in lake elevation since 2012 resulted in an increase in exposed unvegetated shoreline. In the west portion of the South Tufa area exposed playa is typically fairly wet due to spring flow, and mudflats are found in this area. In 2015, it was apparent that wet meadow vegetation had begun to colonize the areas of shoreline that have been exposed since 2012. To the east in the Navy Beach area (Figure 17), the shoreline is generally drier and sandier than the western portion of South Tufa. The brackish pond that developed in 2014 was still present throughout summer of 2015. By September the lake level had declined another 0.6 feet and this brackish pond had dried resulting in a dry sandy beach during the fall period.

Rush Creek (RUCR)

Rush Creek, the largest stream in the Mono Basin, has primarily a snowmelt-driven hydrologic regime with peak stream flows occurring during the spring snowmelt season, and reduced flows the remainder of the year. Peak flows typically occur in June or July in any one year, but may also occur in April or May, particularly in dry years (Beschta 1994). There is a long history of water diversion of Rush Creek waters for irrigation dating back to the 1860's. Water diversion by LADWP began in 1941, resulting in a dry channel in the lower reaches of the creek in some years. Notable large runoff events occurring in 1967, 1969, and the early 1980's, caused substantial incision and scouring due to an absence of riparian vegetation to protect the banks and stabilize the soils. Incision of floodplains drained shallow ground water tables and left former side channels stranded above the newly incised main stream channel (SWRCB 1994). Under Decision 1631, LADWP was required to develop a stream restoration plan and undertake projects to rehabilitate Rush Creek (LADWP 1996). Channel maintenance and flushing flows, referred to as "stream restoration flows" were established in order to mimic seasonal snowmelt runnoff, with the magnitude based on the hydrological conditions for the year (SWRCB 1994).

The dominant vegetation types in the survey area are riparian shrub, streambar, wet meadow and water. There was no stream restoration flow release in Rush Creek due to the dry year conditions (<68.5% average runoff). The maximum flow observed in lower Rush Creek in 2015 was 79 cfs on June 1. In the Rush Creek delta, flow remained confined to a single channel, and thus less of the delta was flooded in 2015 as compared to 2014 (Figure 18). Deltaic deposits were being colonized by meadow vegetation and willows.

Ranch Cove (RACO)

The Ranch Cove shoreline area is a relatively small area located between Rush Creek and Lee Vining Creek. The shoreline area is generally dry, supporting primarily riparian shrub, rabbitbrush, upland scrub, and barren playa. In 2015, the further decrease in lake elevation improved habitats for waterbirds in the Ranch Cove area as it resulted in the development of lake-fringing ponds that attracted many shorebirds in fall (Figure 19).

Lee Vining Creek (LVCR)

Lee Vining Creek is the second largest stream in the Mono Basin, has primarily a snowmelt-driven hydrologic regime with peak stream flows occurring during the spring snowmelt season, and reduced flows the remainder of the year. Peak flows typically occur in June or July in any one year, but may also occur in April or May, particularly in dry years. Water diversion by LADWP began in 1941, resulting in a dry channel in the lower reaches of the creek in some years. Most of the impacts to the creek as a result of LADWP diversions occurred downstream of Highway 395 (SWRCB 1994). Under Decision 1631, LADWP was required to develop a stream restoration plan and undertake projects to rehabilitate Lee Vining Creek (LADWP 1996). Channel maintenance and flushing flows, referred to as “stream restoration flows” were established in order to mimic seasonal snowmelt runnoff, with the magnitude based on the hydrological conditions for the year (SWRCB 1994).

The dominant vegetation types in the survey area are wet meadow, riparian shrub and forest, and water. Due to the dry runoff year conditions, there was no stream restoration flow in Lee Vining Creek. Stream flows were maintained at base flow and water remained confined to the mainstem. The peak flow observed in Lee Vining in 2015 was 39.8 cfs on July 8. At the mouth of Lee Vining Creek (Figure 20), colonization of deltaic soils by wetland vegetation and willows was evident.

West Shore (WESH)

The majority of the West Shore segment is located immediately east of Highway 395, along a steep fault scarp. Several fractured rock gravity springs (LADWP 1987) and two small drainages, Log Cabin Creek and Andy Thom Creek provide fresh water resources along the shoreline. The West Shore area (Figure 21) supports primarily wet meadow habitat with small amounts of riparian scrub and marsh. Minimal shoreline retraction was noted in this area resulting in only minor increases in the amount of exposed playa.

Restoration Ponds

The DeChambeau Ponds and County Ponds are artificial freshwater pond complexes developed initially in the 1940's. These ponds are flooded using deep artesian wells and water diverted from Mill Creek into Wilson Creek and then sent to the ponds. Management of the restoration ponds is conducted by Inyo National Forest. Both County Ponds were flooded in 2015. There was little open water visible at County Pond West due to the encroachment of emergent vegetation. DeChambeau Ponds 1 and 5 were dry in 2015 while ponds 2-4 were flooded.

Mono Lake Sectors

Each of these 15 segments was assigned into one of five Sectors, based on the type of sediments found in those sectors, and the mechanism of sediment deposition: streamflow, glacial action, lake deposits, or wind erosion (Loeffler 1977). Loeffler argues that the distribution of these sediment types is important for the understanding of groundwater flow in the basin.

Sector 1 is the western portion of the basin, where streamflow and glacial action have been the principal agents of deposition. Coarse sediments occur in this sector along current and former stream courses. The primary deposits are deltaic sands and gravels. The lakeshore segments in Sector 1 include Lee Vining Creek, West Shore, DeChambeau Creek, Mill Creek, Wilson Creek and Black Point. There are numerous springs in Sector 1, creating wet shoreline conditions in many places at various lake elevations.

In Sector 2, streamflow and glacial action have been the principal agents of deposition; however the area is much drier due to the greater distance from the eastern escarpment of the Sierra Nevada, and a lack of springs. The shoreline segments included in this sector are Rush Creek and Ranch Cove. The major water source for Sector 2 is Rush Creek, which is the largest stream in the Mono Basin.

Sector 3 along the southern shore, is composed primarily of volcanic sands, deposited by winds and wave action. Shoreline segments in Sector 3 include South Tufa, South Shore Lagoons, and Sammann's Spring. Longshore currents transport sandy sediments in this Sector, contributing to the dynamic nature of shoreline ponds and wetland features.

Sector 4 in the eastern and northeastern portion of the lake is composed of fine lake sediments transported by lake water or wind, with a fine covering of sand transported by wind. Vegetation colonization of exposed playa areas in Sector 4 is limited. Lakeshore segments in Sector 4 are Warm Springs, Northeast Shore, and Bridgeport Creek.

Sector 5 was classified as a transition area composed of sand and silts. The only lakeshore segment in Sector 5 is DeChambeau Embayment.

Bridgeport Reservoir

Bridgeport Reservoir is located in Bridgeport Valley, at an elevation of 6,460 feet. Bridgeport Reservoir is a small reservoir with a surface area of approximately 12 km^2 and a storage capacity of 42,600 acre-feet. Bridgeport Reservoir captures flows from Buckeye Creek, Robinson Creek and the East Walker River to be used for agricultural purposes in Nevada. Irrigated pastures border the south and southwestern portion of the reservoir while Great Basin scrub is dominant elsewhere.

The three shoreline segments of Bridgeport Reservoir are North Arm, West Bay and East Shore (Figure 22). The North Arm includes primarily sandy beaches bordered by upland vegetation (Figure 23). The West Bay receives fresh water inflows from Buckeye and Robinson Creeks and the East Walker River, creating extensive mudflat areas adjacent to these creek inflow areas, especially when the reservoir is at a higher level. The East Shore includes some mudflat and meadow areas in the vicinity of the East Walker River, but the majority of the East Shore area is bordered by Great Basin scrub or exposed reservoir bottom.

The water level of Bridgeport Reservoir continued to be well below the maximum storage capacity, however the water level was slightly higher in fall 2015 as compared to 2014. In September 2015, Bridgeport Reservoir held 3,160 acre-feet (Department of Water Resources, California Data Exchange Center, (http://cdec.water.ca.gov/cgi-progs/queryMonthly?s=BDP&d=today), which represents almost a 70% increase in the number of acre-feet than at the same time in 2014. The increased amount of water in the reservoir as compared to fall 2014 resulted in an increase in the amount of open water habitat primarily in the West Bay.

Crowley Reservoir

Crowley Reservoir is located in Long Valley, at an elevation of 6,780 feet. Crowley Reservoir is the second largest lake in Mono County, and the largest reservoir in the county, averaging 21.4 km^2 and with a storage capacity of 183,465 acre-feet.

The major source of fresh water input at Crowley Reservoir occurs via the Owens River. Other fresh water input includes flow from McGee and Convict Creeks, Layton Springs, and subsurface flow from springs along the west shore. Vegetation communities immediately surrounding Crowley Reservoir include irrigated pasture, wet meadow, Great Basin scrub, alkali meadow, and exposed shoreline.

In early September, Crowley Reservoir held 102,966 acre-feet (Department of Water Resources, California Data Exchange Center, http://cdec.water.ca.gov/cgi-progs/queryMonthly?s=crw&d=today) which represents an increase of 30% in the number of acre-feet as compared to September 2014.

The shoreline of Crowley Reservoir was divided into seven segments (Figure 24, Appendix 2).

Upper Owens (UPOW)

The Upper Owens area includes large areas of exposed mudflats and reservoir bottom adjacent to the mouth of the Owens River. With declining reservoir levels, meadow vegetation has colonized areas of exposed reservoir bottom adjacent to the river channel in the Upper Owens area (Figure 25).

Sandy Point (SAPO)

Most of the length of Sandy Point area (Figure 26) is bordered by cliffs or upland vegetation. Small areas of meadow habitat occur in this area and limited freshwater input occurs at Green Banks Bay.

North Landing (NOLA)

The North Landing area is influenced by subsurface flows and supports meadow and wet meadow habitat, particularly near the western border (Figure 27).

McGee Bay (MCBA)

The McGee Bay shoreline area (Figure 28) supports vast mudflat areas immediately adjacent to wet meadow habitats. McGee Creek and Convict Creek are tributary to Crowley Reservoir in this shoreline area. Other sources of water include spring flow and subsurface flow from irrigation upgradient.

Hilton Bay (HIBA)

The Hilton Bay area includes Big Hilton Bay to the north and Little Hilton Bay to the south (Figure 29). The Hilton Bay area, surrounded by meadow and sagebrush habitat, receives small amounts of fresh water input from Hilton Creek and spring flow.

Chalk Cliffs (CHCL)

Chalk Cliffs (Figure 30) lacks fresh water inflow areas or wetland habitats, and is dominated by sandy beaches adjacent to steep, sagebrush-covered slopes.

Layton Springs (LASP)

The Layton Springs shoreline area is bordered by upland vegetation and a large area of sandy beach (Figure 31). Layton Springs provides fresh water input at the southern border of this lakeshore segment.

METHODS

Summer Ground Surveys

Mono Lake

Three ground-count and brood surveys were conducted at Mono Lake at three-week intervals beginning in early June. All surveys were conducted as area counts, and locations were surveyed either by walking along the shoreline, along creek corridors or by making observations from a stationary point. Ground surveys of all shoreline locations were completed over four to five-days.

Shoreline locations surveyed were those identified in the Plan as current or historic waterfowl concentration areas, namely: South Tufa, South Shore Lagoon, Sammann's Spring, Warm Springs, Wilson Creek, Mill Creek, DeChambeau Creek Delta, Rush Creek Delta, and Lee Vining Creek and delta. Surveys were also conducted at the restoration ponds north of the lake: DeChambeau Ponds and County Ponds.

Shoreline areas were surveyed by traversing the entire shoreline segment on foot, following the shoreline. In Rush Creek and Lee Vining Creek, the survey area included the creek channels from the County Road downstream to the deltas, and the shoreline area within approximately 100 meters on either side of the deltas. At the Restoration Ponds, observations were taken from stationary points that allowed full viewing of each pond. A minimum of five minutes was spent at each observation point at the DeChambeau and County Ponds.

All summer ground surveys began within one hour of sunrise and were completed within approximately six hours. The order in which the various sites were visited was varied in order to minimize the effect of time-of-day on survey results. Surveys were conducted by walking at an average rate of approximately 1.5 km/hr, depending on conditions, and recording waterfowl species as they were encountered. Total survey time was recorded for each area. The date and time of day for each survey during 2015, are provided in Appendix 3.

The following was recorded for each waterfowl observation: time of the observation; the habitat type being used; and an activity code indicating how the bird or birds were using the habitat. Examples of activities recorded include resting, foraging, flying over, nest found, brooding, sleeping, swimming, and calling.

Brood Surveys

While conducting summer ground counts at Mono Lake, emphasis was placed on finding and recording all waterfowl broods. Because waterfowl are easily flushed, and females with broods are especially wary, the shoreline was frequently scanned well ahead of the observer in order to increase the probability of detecting broods. Information recorded for broods included species, brood size, GPS coordinates (UTM, NAD 83, Zone 11, CONUS), habitat use, and age. Broods were aged based on plumage and body size (Gollop and Marshall 1954).

Since summer surveys were conducted at three-week intervals, any brood assigned to Class I using the Gollop and Marshall age classification scheme would be a brood that had hatched since the previous visit. Assigning an age class to broods allowed for the determination of the minimum number of “unique broods” using the Mono Lake wetland and shoreline habitats.

Habitat Use

The habitat being used by waterfowl was recorded in order to evaluate habitat selection by waterfowl at Mono Lake. The habitat categories generally follow the classification system found in Mono Lake Landtype Inventory, 2014 Conditions (LADWP 2014) (Appendix 1). The specific habitat categories used in that mapping effort (and in this project) include: marsh, wet meadow, alkaline wet meadow, dry meadow/forb, riparian scrub, Great Basin scrub, riparian woodland, freshwater stream, ria, freshwater pond, brackish pond, hypersaline pond, and unvegetated. Salinity measurements of ponds were taken using an Extech EC400 Conductivity/TDS/Salinity probe in order to aid in the proper classification of fresh versus brackish ponds when recording habitat use. Ponds with a salinity of less than 500 ppm were classified as fresh. Ponds with vegetation present and a salinity of greater than 500 ppm were classified as brackish. Ponds with a measured salinity greater than 10 g/L (the maximum range of the probe) lacking vegetation and subsurface or surface freshwater inflow were classified as hypersaline. Two additional habitat types: open-water near-shore (within 50 meters of shore), and open-water offshore (>50 meters offshore), were added to the existing classification system in order to more completely represent areas used by waterfowl.

Fall Aerial Surveys

Overview of Methodology

Aerial surveys were conducted in the fall at Mono Lake, Bridgeport Reservoir, and Crowley Reservoir using a small high-winged airplane. A total of six surveys were conducted at two-week intervals, with the first survey beginning during the first week of September, and the final fall survey occurring in the middle of November. In all cases, surveys of all three waterbodies were completed in a single flight by 1200 hours on the day of the survey. A summary of the fall survey schedule has been provided as Appendix 4.

LADWP contracted with Black Mountain Air Service to conduct fixed-winged aerial counts. Black Mountain Air Service has obtained a low-altitude flight waiver from the Federal Aviation Administration in order to conduct these flights. Aerial surveys were conducted in a Cessna 180 at a speed of approximately 130 kilometers per hour, and at a height of approximately 60 meters above ground. Observations were verbally recorded onto a handheld digital audio recorder and later transcribed by the observer. Two observers other than the pilot were present on all six flights.

Ground verification counts were conducted whenever flight conditions (e.g., lighting, background water color, etc.) did not allow the positive identification of a significant percentage of the waterfowl encountered, or to confirm the species or number of individuals present. During a ground validation count, the total number of waterfowl present in an area was recorded first, followed by a count of the number of individuals of each species present.

Mono Lake

Aerial surveys of Mono Lake consisted of a perimeter flight of the shoreline and a set of fixed cross-lake transects. Waterfowl and shorebirds were censused, with the primary emphasis on counting waterfowl. Each aerial survey began at Mono Lake at approximately 0900 and was completed in approximately one and one-half hours.

Shoreline Census

Shoreline surveys were conducted over water in a counterclockwise direction while maintaining a distance of approximately 250 meters from shore. The second observer sat on the same side of the plane as the primary observer during the perimeter flight and censused shorebirds and waterfowl.

Crosslake Transects

The cross-lake transects, conducted immediately after the shoreline census, cover open water areas of Mono Lake. The eight transects are spaced at one-minute (1/60 of a degree, approximately one nautical mile) intervals and correspond to those used by Boyd and Jehl (1998) for the monitoring of Eared Grebes during fall migration. The latitudinal alignment of each transect is provided in Appendix 5.

Each of the eight transects is further divided into two to four sub-segments of approximately equal length (Figure 32). The total length of each cross-lake transect was first determined from a 2002 aerial photo. These lengths were then sub-divided into the appropriate number of subsections to a total of twenty-five sub-segments, each approximately 2-km in length. This approach creates a grid-like sampling system that allows for the evaluation of the spatial distribution of species occurring offshore. The beginning and ending points for each subsection were determined using landscape features, or, when over open water, by using a stopwatch, since the survey aircraft's airspeed was carefully controlled and the approximate length of each subsection was known.

During the cross-lake transect counts, observers sat on the opposite sides of the plane and counted Ruddy Ducks and other waterfowl, and phalaropes occurring on the open water.
In order to reduce the possibility of double-counting, only birds seen from or originating from the observer's side of the aircraft were recorded. Even though the flight path of the aircraft along the latitudinal transects effectively alternated the observer's hemisphere of observation in a North-South fashion due to the aircraft's heading on successive transects, the one-nautical-mile spacing between the transects worked in conjunction with the limited detection distance of the waterfowl (<< 0.5 nautical mile) to effectively prevent double-counting of birds on two adjacent transects.

Bridgeport Reservoir

The survey flights started at the dam at the north end of the reservoir and proceeded counterclockwise. The distance from shore, flight speed, and height above ground were the same as employed at Mono Lake. Adjustments were made as necessary depending on lighting, lake level and waterfowl distribution. The reservoir was circumnavigated twice during each survey to allow for a second count of often large concentrations of mixed species flocks. The second observer sat on the same side of the plane as the primary observer during the entire survey, and assisted in waterfowl counts.

Crowley Reservoir

Each survey began at the mouth of the Owens River and proceeded over water in a counterclockwise direction along the shoreline. The distance from shore, flight speed, and height above the water were the same as at Mono Lake during most of each flight. Temporary diversions of distance from shore or height above ground were made by the pilot as necessary to avoid direct or low flight over float-tube recreationists or boats. Adjustments were also made as necessary depending on lighting, lake level and waterfowl distribution. The reservoir was circumnavigated twice during each survey to allow for a second count of often large concentrations of mixed species flocks. At Crowley, the second observer sat on the same side of the plane as the primary observer during the entire survey, and assisted in waterfowl counts.

Data Summary and Analysis

Summer Ground Count Data

Total waterfowl detections were summed for all three surveys, by individual survey, and lakeshore segment. Descriptive statistics were calculated for each of these indices including the long-term means for the time period 2002-2015. The number of individuals of each species was summed by survey. Spatial distribution patterns for 2015 were evaluated by summing the total waterfowl encountered in each lakeshore segment and comparing the distribution to that of the long-term mean.

The total number of broods by species, survey and lakeshore segment were summed. Descriptive statistics were calculated on brood data for the time period 2002-2015 including mean total lakewide broods and mean number of broods per lakeshore segment, and average brood size.

Waterfowl habitat observations, excluding flyover were summed for all species. Although a ">50 meter" category was used at the time of data collection, these observations will not be included in the final calculations unless the presence of waterfowl in the open-water offshore zone was determined to be due to observer influence (e.g., the observer sees that a female duck is leading her brood offshore and is continuing to swim away from shore).

The common names and scientific names for waterfowl species encountered can be found in Appendix 6.

Fall Aerial Count Data

For each lake, total waterfowl by survey, lakeshore segment and species was summed. Descriptive statistics were calculated for each of these indices including the long-term means for the time period 2002-2015. The spatial distribution of waterfowl at each lake was determined by calculating the proportion of all fall detections that occurred in each lakeshore segment or offshore (for Mono Lake). This calculation was done excluding Ruddy Duck numbers at Mono Lake.

Waterfowl Populations vs. Lake Elevation

Although many factors likely affect waterfowl use of Mono Lake, the primary waterfowl habitat restoration goal identified in the Plan is to increase the level of Mono Lake to the target level of 6,392 feet. From 2002-2015, Mono Lake has experienced two periods of increasing lake elevation followed by decreases in lake elevation, and in 2015 was at the lowest level in 20 years. Waterfowl data were analyzed using simple linear regression to determine if there has been a response to lake elevation changes. Simple linear regression was used to evaluate the relationship between lake elevation and summer waterfowl abundance and total number of broods detected. Fall waterfowl populations at Mono Lake were evaluated for correlations between total waterfowl detections. This analysis was also conducted for Bridgeport and Crowley Reservoir as a comparison.

RESULTS

Summer Ground Surveys

Shoreline waterfowl abundance, distribution and brood counts

A total of 862 waterfowl were recorded during summer surveys over the three surveys (Table 1). The total number of waterfowl using the shoreline (exclusive of dependent young) detected during summer surveys was highest (375) during Survey 1 in early June, and lowest (220) on the late July survey (Survey 3) (Table 1). The number of waterfowl observed on survey 1 and survey 2 was below the long-term mean, however no decreases were observed when comparing the results of survey 3 (Figure 33). The total number of waterfowl observed summed over all three surveys in 2015 was below the 2002-2015 average of 993 +/-63.

A total of twelve waterfowl species were detected during summer lakeshore counts (Table 1). Of these twelve species, breeding was confirmed for Canada Goose, Gadwall, Green-winged Teal and Mallard. Cinnamon Teal, Northern Pintail and Ruddy Duck have nested around Mono Lake in previous years, but no evidence of nesting by these species was seen around the shoreline in 2015. Several species encountered in 2015 were transitory or oversummering individuals including Redhead, Blue-winged Teal, Brant, Hooded Merganser, and Bufflehead. The most abundant species was Gadwall accounting for 50% of all detections (426/862). Other common species were Canada Goose (19%), Mallard (13%) and Green-winged Teal (11%).

The majority of waterfowl were found either in the South Shore Lagoons area at Goose Springs, along the northwest shore in the DeChambeau Creek, Mill Creek and Wilson Creek areas, and

Warm Springs (Figure 34). The fewest number of waterfowl were found at Lee Vining Creek and South Tufa. Total waterfowl use of the Warm Springs area was well above the long-term mean. Waterfowl use of Lee Vining Creek, Mill Creek, Rush Creek, Sammann's Spring and Wilson Creek were below the long-term mean.

Waterfowl species observed with broods in the lake-fringing wetlands and creeks at Mono Lake in 2015 were Canada Goose, Gadwall, Green-winged Teal, and Mallard (Table 2). A total of 38 broods were found with Gadwall comprising the majority of broods found (25/38; 66%). The number of broods observed in 2015 at Mono Lake was below the 2002-2015 mean of 53.0 +/- 4.6. The highest number of waterfowl broods were found in the South Shore Lagoons area, primarily in the Goose Springs area (Figure 35). Six broods were seen at Warm Springs which is the most broods that have ever been observed at this site, and well above the long-term mean for this area. In most years, no broods are found at Warm Springs. The number of broods was below the long-term mean at the following locations: DeChambeau Creek, Mill Creek, Wilson Creek, Lee Vining Creek and Sammann's Spring. The average brood size for all waterfowl species in 2015 was 4.55 +/- 0.45 SEM, which is below the long-term mean of 5.95 +/- 0.13 SEM.

Habitat Use

The habitats waterfowl were observed in most frequently were ria (outflow areas of springs and creeks), brackish ponds and freshwater ponds (Table 3). Broods were seen primarily in freshwater ponds and ria. Most observations of waterfowl foraging were in ria, although brackish ponds were also used frequently. Brackish ponds were the main habitat type used for resting and sleeping.

<u>Fall Aerial Surveys</u>

Fall Aerial Survey Weather Conditions

The first storm of the season arrived in early October resulting in stormy, breezy conditions during the October 2 survey. Just prior to the October 30 survey, on October 29 a cold, windy winter storm affected the area, bringing with it the first significant freeze. A third fall storm on November 10, just prior to the final fall survey brought significant snow to the Sierra Nevada and light snow down to the valley floors of Mono County. By the mid-November flight, shoreline ponds at Mono Lake were frozen and a thin layer of ice was developing in some portions of the reservoirs.

Mono Lake

A total of eleven waterfowl species and 16,882 individuals were recorded at Mono Lake during fall aerial surveys of shoreline and cross-lake transects (Table 4). Total waterfowl numbers varied through the season with the peak numbers occurring early in September, and then generally decreasing through fall. The peak number of total waterfowl detected at Mono Lake on any single count was 8,437 and occurred on the September 2 survey (Table 4). The fewest number of waterfowl (596) were observed on the final fall survey on November 12. Northern Shoveler (*Anas clypeata*) and Ruddy Duck (*Oxyura jamaicensis*) were the dominant species during fall migration with Northern Shoveler accounting for 72.7% (12,270), and Ruddy Duck accounting for 20.1% (3,563) of all detections. These two species showed a different temporal pattern of abundance at Mono Lake as Northern Shoveler were present in large numbers only through mid-September, with the fall survey high count of 8,122 observed on the September 2 survey, while Ruddy Ducks were most abundant during October, with the fall survey high count of 1,042 on the October 2 survey. Total waterfowl use at Mono Lake in fall 2015 was below the long-term mean (Figure 36). Ruddy Duck use was well below the long-term mean, contributing significantly to the overall decrease in total waterfowl use.

Over 80% of all shoreline detections of waterfowl in the fall were in the northwest shore area (Sector 1), with the majority observed in Wilson and Mill Creeks (Figure 37). Waterfowl use of the northwest shore areas in Sector 1 (namely Wilson Creek) was proportionally more than the long-term mean. Although overall waterfowl numbers were not high at Warm Springs due to limited habitat, the Warm Springs (Sector 4) also received higher use than normal. Areas that received decreased use include Rush Creek in Sector 2 and South Shore Lagoons and Sammann's Spring in Sector 3.

Bridgeport Reservoir

A total of fifteen waterfowl species and 25,817 individuals were recorded at Bridgeport Reservoir during fall aerial surveys (Table 5). Total waterfowl numbers varied only slightly through the season as compared to other years at this location. Total numbers of waterfowl were highest in September, decreasing slightly through fall. The peak number of total waterfowl detected at Bridgeport on any single count was 5,434 and occurred on the September 17 survey (Table 5). The fewest number of waterfowl (3,035) were observed on the final fall survey on

November 12. Northern Shoveler, Gadwall and Canada Goose were the dominant species during fall migration with Northern Shoveler accounting for 25.9% (6,674), Gadwall 14.5% (3,744) and Canada Goose 12.1% (3,129) of all detections. These species showed a different temporal pattern of abundance as Northern Shoveler was present in higher numbers through mid-September, Gadwall was most abundant early September, and Canada Goose numbers increased through fall with the highest number on the final survey on November 12. Similar to Mono Lake, total waterfowl use at Bridgeport Reservoir in fall 2015 was below the long-term mean (Figure 38). Ruddy Duck use was slightly higher, while Northern Shoveler was only slightly below average.

Over 80% of all waterfowl in were in the West Bay area, representing a slight reduction in average use (Figure 39). Waterfowl use of the East Shore area was higher in 2015.

Crowley Reservoir

A total of sixteen waterfowl species and 65,133 individuals were recorded at Crowley Reservoir during fall aerial surveys (Table 6). Total waterfowl numbers were later in the season than the other two lakes with the highest numbers in October and a peak count of 16,117 on the October 2 survey (Table 6). The fewest number of waterfowl (8,378) were observed on the final fall survey on November 12. Ruddy Duck, Northern Shoveler, Mallard and Northern Pintail were the dominant species during fall migration with Ruddy Duck accounting for 34.2% (22,298), Northern Shoveler 22.6% (14,728), Mallard 12.8% (8,365) and Northern Pintail 11.1% (7,219) of all detections. These species showed a different temporal pattern of abundance as Ruddy Duck was most abundant throughout October, Northern Shoveler in September, Mallard in late October, and Northern Pintail early to mid-October. Unlike the Mono Lake and Bridgeport Reservoir, total waterfowl use in fall 2015 was above the long-term mean (Figure 40). Ruddy Duck use was well above the long-term mean and Northern Shoveler use was also increased.

The main areas of waterfowl use were McGee Bay and Upper Owens as these two areas attracted almost 90% of the total (Figure 41). The overall highest use continued to be in McGee Bay, although the Upper Owens attracted proportionally more waterfowl than usual.

Mono Lake Restoration Ponds

A total of six species and 65 waterfowl were detected at the Restoration Ponds during summer surveys (Table 7). Most of the waterfowl use was in County Pond East. The most abundant species at the Restoration Ponds were Gadwall, Ruddy Duck and Cinnamon Teal. Gadwall was the only species seen with broods at the Restoration Ponds in 2015 (Table 8). Eight Gadwall broods were found, with six of these at County Pond east.

A total of seven waterfowl species and 211 individuals were recorded at the Restoration Ponds in fall (Table 9). This was just slightly below the long-term mean of 382 +/- SEM 164. At County Ponds, only 20 of the 116 waterfowl were observed in County Pond west. At DeChambeau Ponds, the majority of use was in DeChambeau Pond 4 which held 70 of the 95 birds seen. No waterfowl were observed in Pond 1 or 5.

Waterfowl Populations vs. Lake Elevation

There is a trend towards increased waterfowl use in summer as a function of increased Mono Lake elevation in June but this relationship is not statistically significant ($r = 0.52$, $p = 0.055$, Figure 42). The number of broods detected has been significantly positively correlated with the lake elevation in June ($r = 0.80$, $p < 0.01$) (Figure 43).

There has been no correlation between total fall waterfowl numbers and Mono Lake elevation in September ($r = 0.07$, $p = 0.79$) (Figure 44). The number of waterfowl using Bridgeport has been positively correlated with reservoir level, while at Crowley Reservoir no relationship has been observed.

SUMMARY

Based on waterfowl counts and field observations, the conditions for breeding waterfowl in 2015 were not favorable in many lakeshore segments, but stable to improved in others. The reduced total number of waterfowl on surveys 1 and 2 as compared to the long-term mean suggests either a reduction in migrant use (primarily survey 1), or early departure of breeding birds (survey 2). Although the elevation of Mono Lake was over one foot lower than during the waterfowl breeding period in 2014, and conditions in some lakeshore areas appeared poor, brood numbers were slightly higher than 2014, but still below the long-term mean. This is likely due to the response of waterfowl to local habitat conditions around the lake. Declines in breeding waterfowl use at many lakeshore segment areas are likely a result of changes observed in habitat quality due to decreased lake elevation. At Mono Lake, waterfowl and their broods are most often observed feeding onshore at the outflow of creeks or one of the numerous springs around the lake, or in the somewhat limited and broadly dispersed fresh water ponds. At higher lake elevations, these preferred feeding areas are in close proximity to the shoreline, and therefore also closer to cover afforded by wetland vegetation. In many areas, most notably Sammann's Springs and Wilson Creek, preferred feeding areas were far from cover and nesting sites in 2015 due to shoreline retraction. The use of Sammann's Springs and Wilson Creek by breeding waterfowl in was below that of the long-term mean, possibly due to poor conditions. Breeding waterfowl use of South Shore Lagoons area was maintained despite similar shoreline retraction. In the South Shore Lagoons area, a series of small, freshwater ponds is typically present around Goose Springs. The large freshwater pond that is now in this area just west of Goose Springs is a result of the formation of a large sandbar that developed from wind and wave action, and a change that is typical of the dynamic nature of this area of lakeshore. This large complex of freshwater ponds present in the Goose Springs area in 2015 attracted breeding waterfowl due to their open water nature, and nearby adjacent cover. Brooding female ducks generally select habitats that have high invertebrate populations and dense vegetative cover (Baldassarre and Bolen 1994). The near-shore ponds, when present, provide invertebrates required by ducklings for growth and development, and often dense vegetative cover nearby. Some of the fresh water ponds at Mono Lake such as those that occur at the outflow of the Goose Springs complex in the South Shore Lagoons area, have been stable and present since at least 2002. The increased use of Warm Springs may have also been in response to local conditions. The above-normal late-spring rains resulted in wide-spread flooding of many depressions in this area, forming ephemeral to seasonal freshwater ponds. The favorable conditions created at Warm Springs, combined with poor conditions elsewhere, may have attracted a greater proportion of breeding waterfowl to this area. Waterfowl encountering poor conditions at Sammann's Springs or other shoreline areas may have settled in Warm Springs because of improved conditions from spring and summer rains. Waterfowl exhibit breeding site philopatry (Krapu et al 1983) and thus may return to Mono Lake to breed, but be responsive to local conditions at wetland sites around the lake.

The fall results indicate overall reduced use of Mono Lake and Bridgeport Reservoir in 2015, but an increased use of Crowley Reservoir. The low number of Ruddy Ducks observed at Mono Lake accounts for much of the reduction in overall numbers as this species has often comprised 40-60% of the total fall waterfowl counts. High numbers of this species were seen at Crowley Reservoir and slightly increased numbers at Bridgeport suggesting that Ruddy Duck numbers overall were not significantly decreased in the region, yet Ruddy Ducks were responding to conditions at Mono Lake in particular. Limited food resources at Mono Lake is one possible explanation for reduced numbers of Ruddy Ducks at Mono Lake. Johnson and Jehl (2002) state that alkali fly larvae appear to be the main food item of Ruddy Ducks at Mono Lake in fall. While no data are available on alkali fly populations at Mono Lake, the alkali fly is known to require firm substrates such as pumice blocks, tufa, or beach rock (Jones and Stokes 1993) to attach their pupae to. The highest numbers of Ruddy Ducks at Mono Lake are generally found along the northern shore, east of DeChambeau Embayment. The DeChambeau Embayment supports large areas of pumice blocks which may serve at attachment points for alkali fly pupae. Due to the decrease in lake elevation, many of the pumice blocks in the DeChambeau Embayment area have become exposed. Appropriate attachment surfaces such as delta beach rocks, and tufa in many other shoreline areas are also currently exposed as well. In addition, the effect of decreasing lake elevations on the food resources for alkali flies is unknown.

The lack of a simple, direct relationship between fall use by waterfowl and Mono Lake elevation may be due to a few different factors. Dabbling duck use has been confined primarily to areas with fresh water influence, namely spring outflow areas, fresh water ponds and brackish ponds. Due to the dynamic nature of the Mono Lake shoreline, the abundance of these habitat types is not directly correlated with lake elevation. The varying effects of lake elevation changes, wind, erosion, and even variations in rainfall across the landscape lead to habitat conditions that change seasonally and yearly.

Fall waterfowl use of Bridgeport Reservoir has been influenced by water levels either directly or indirectly. Water levels at Bridgeport appear to influence waterfowl habitat primarily by affecting the amount of flooding at the south end of the reservoir, where the majority of waterfowl congregate. The south end of the reservoir is expected to have the best feeding areas for migratory waterfowl as these areas are adjacent to creek inflows, shallow areas preferred by most species of dabbling ducks, and seasonally-flooded irrigated pastures and meadows. Due to the low gradient of the land at the south end of the reservoir, small increases in reservoir level may result in large changes in the amount of waterfowl habitat available.

At Crowley Reservoir, the lack of a relationship between waterfowl use and reservoir level may be due to a number of factors including different shoreline configuration, a narrower range of values of “low” and “high” observed, and different response of food resources, among others.

The proportional abundance of waterfowl species at Mono Lake differs greatly from that of the nearby freshwater reservoirs as the fall waterfowl population at Mono Lake is dominated by Northern Shoveler and Ruddy Duck, while waterfowl populations at the reservoirs are much more diverse. The food resources of a fresh water reservoir little resemble those of Mono Lake, and thus waterfowl using Mono Lake encounter and are responding to a different set of environmental variables.

Migratory waterfowl populations that use Mono Lake are expected to be influenced by a multitude of factors. Short-term and long-term population trends will be affected by conditions on breeding grounds, wintering grounds, and along migratory routes. Mono Lake provides abundant food resources for the limited number of waterfowl species that are able to exploit those resources. Important waterfowl habitats at Mono Lake such as brackish and freshwater ponds are ephemeral in nature as the shoreline configuration is dynamic, changing as a result of lake elevation changes and the effect of wind on the shoreline.

RECOMMENDATIONS

Under the Mono Basin Implementation Plan (LADWP 2000a), the monitoring of waterfowl populations in the Mono Basin was to continue until at least the year 2014, or until the targeted lake level (6,392 foot elevation) was reached and the lake cycled through a complete wet/dry cycle. Recovery of lake elevation to the target level is taking longer than anticipated and predicted by previous models and Mono Lake has not yet reached the targeted lake elevation since implementation of the Plan. In addition, over the last five years, the lake elevation has dropped approximately 6 feet due to successive years of below-average precipitation. In 2010, Watercourse Engineering and LADWP reevaluated Mono Lake elevation predictions using a 31-year dataset (1980-2010). Based on reiterative runs of the model, the average length of time predicted for Mono Lake to reach the targeted lake level of 6,392 feet at that time was 17 years (range of 3-25 years).

Taking into consideration that the targeted lake elevation may not be reached for quite some time, it seems prudent to reevaluate the waterfowl monitoring program at this point. I recommend that the results of the waterfowl monitoring program from 2002-2015 be analyzed and synthesized in a report. The report will include a comparison of lake, local and regional trends, an analysis of the response of waterfowl to lake level, limnological and vegetation factors, an analysis of the efficiency of the program, and the efficacy of the program at fulfilling both the requirements and intent of the Plan. Recommendations for modifications to the current program or for management of waterfowl habitat at Mono Lake will also be addressed.

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Table 1. 2015 Summer Ground Count Data by Survey

Species	Survey 1	Survey 2	Survey 3	Total	Percent Detections
Canada Goose	39	59	62	160	18.6%
Cinnamon Teal	11	10	18	39	4.5%
Gadwall	219	124	83	426	49.4%
Green-winged Teal	31	43	20	94	10.9%
Mallard	62	19	28	109	12.6%
Northern Pintail	7			7	0.8%
Redhead			2	2	0.2%
Ruddy Duck	5	10	4	19	2.2%
Blue-winged Teal		2		2	0.2%
Brant	1		1	2	0.2%
Hooded Merganser			1	1	0.1%
Bufflehead			1	1	0.1%
Total Waterfowl	375	267	220	862	

Table 2. 2015 Brood Data

Table shows the total number of broods by species per shoreline survey area

Shoreline Segment	DECR	LVCR	MICR	RUCR	SASP	SOTU	SSLA	WASP	WICR	**Total**
Canada Goose						1				**1**
Gadwall	1		4	1	1		12	2	4	**25**
Green-winged Teal			1	4				1		**6**
Mallard		1		1			1	3		**6**
Total broods per area	1	1	5	6	1	1	13	6	4	38

Table 3. Waterfowl habitat use

	Activity							
Habitat	Brooding	Calling	Flushed	Foraging	Nesting	Resting	Swimming	Total
Wet Meadow				30	9			39
Alkaline Meadow			1					1
Freshwater Stream	6	1	14			2	1	24
Ria	13		5	251		2		271
Freshwater Pond	17		15	35		13	43	123
Brackish Pond	7	1	10	94		63		175
Great Basin Scrub			1					1
Unvegetated						19		19
Open Water				7			35	42
Total by activity	43	2	46	417	9	99	79	695

Table 4. 2015 Mono Lake Fall Aerial Survey Count Data

Species	2-Sep	17-Sep	2-Oct	13-Oct	30-Oct	12-Nov	Total detections	% Total
Greater White-fronted Goose						12	12	0.1%
Snow Goose						2	2	<0.1%
Canada Goose	12		18	59	15	8	112	0.7%
Gadwall	121	4	67	64		12	268	1.6%
Mallard	36	33	2	30	72	60	233	1.4%
Cinnamon Teal	5						5	<0.1%
Northern Shoveler	8122	3904	211	8	22	3	12270	72.7%
Northern Pintail	12	20	10	6			48	0.3%
Green-winged Teal	59				71	63	193	1.1%
Unidentified Teal		1	137	16	12	8	174	1.0%
Bufflehead	2						2	<0.1%
Ruddy Duck	68	491	1042	663	871	428	3563	21.1%
Total Waterfowl	8437	4453	1487	846	1063	596	16882	

Table 5. 2015 Bridgeport Reservoir Fall Aerial Survey Count Data

Species	2-Sep	17-Sep	2-Oct	13-Oct	30-Oct	12-Nov	Total detections	% Total
Greater White-fronted Goose					20		20	0.1%
Canada Goose	403	340	360	633	675	718	3129	12.1%
Tundra Swan						9	9	<0.1%
Gadwall	1430	600	178	660	586	290	3744	14.5%
American Wigeon				100	22	50	172	0.7%
Mallard	130	60	912	602	629	465	2798	10.8%
Cinnamon Teal		5					5	<0.1%
Northern Shoveler	1760	3360	1349	20	123	62	6674	25.9%
Northern Pintail	40	100	300	400	560	425	1825	7.1%
Green-winged Teal	700	300	700	600	432	875	3607	14.0%
Unidentified Teal	400	60		40			500	1.9%
Redhead		1			30	20	51	0.2%
Ring-necked Duck	50				8	12	70	0.3%
Bufflehead			26		72	80	178	0.7%
Common Merganser	6	3	8		2	25	44	0.2%
Ruddy Duck	100	605	1126	675	481	4	2991	11.6%
Total Waterfowl	5019	5434	4959	3730	3640	3035	25817	

Table 6. 2015 Crowley Reservoir Fall Aerial Survey Count Data

Species	2-Sep	17-Sep	2-Oct	13-Oct	30-Oct	12-Nov	Total detections	% Total
Canada Goose	40	141	32	29	150	70	462	0.7%
Tundra Swan					4	15	19	<0.1%
Gadwall	922	383	2115	878	366	413	5077	7.8%
American Wigeon	35	20	110	120	110	16	411	0.6%
Mallard	400	420	2070	1650	3426	399	8365	12.8%
Cinnamon Teal	62					2	64	0.1%
Northern Shoveler	3603	4990	2670	239	614	2612	14728	22.6%
Northern Pintail	727	652	2360	2670	250	560	7219	11.1%
Green-winged Teal	997	448	1340	520	846	706	4857	7.5%
Unidentified Teal	15					300	315	0.5%
Canvasback					80	214	294	0.5%
Redhead	4		170	30	6	12	222	0.3%
Ring-necked Duck	6		30	40	44	40	160	0.2%
Lesser Scaup					56	45	101	0.2%
Bufflehead			3	31	152	318	504	0.8%
Common Merganser			7			30	37	0.1%
Ruddy Duck	3120	1860	5210	4825	4657	2626	22298	34.2%
Total Waterfowl	9931	8914	16117	11032	10761	8378	65133	

Table 7. 2015 Mono Lake Restoration Ponds - Total Summer Detections

Species	COPOE	COPOW	DEPO_1	DEPO_2	DEPO_3	DEPO_4	DEPO_5	Total
Gadwall	21			1		7		29
Mallard	4					1		5
Cinnamon Teal				10	2			12
Green-winged Teal				3				3
Redhead	1							1
Ruddy Duck	8			3		4		15
Pond Totals	34	0	0	17	2	12	0	65

Table 8. Mono Lake Restoration Ponds - Total Waterfowl Broods

Species	County Ponds	DeChambeau Ponds
Gadwall	6	2
Total Broods	6	2

Table 9. Mono Lake Restoration Ponds - 2015 Fall Survey Counts

County Ponds	2-Sep	17-Sep	2-Oct	13-Oct	30-Oct	12-Nov	Total Fall Detections
Gadwall	5	20		5			30
Green-winged Teal					5		5
Mallard			15	15			30
Northern Shoveler	30	20					50
Total Waterfowl	35	40	15	20	5	1	116

DeChambeau Ponds	2-Sep	17-Sep	2-Oct	13-Oct	30-Oct	12-Nov	Total Fall Detections
Gadwall	8	10		14			32
Mallard		10	2			4	16
Northern Pintail					3		3
Northern Shoveler	20						20
Ruddy Duck	4				7		11
Unidentified Teal		2	7			4	13
Total Waterfowl	32	22	9	14	10	8	95

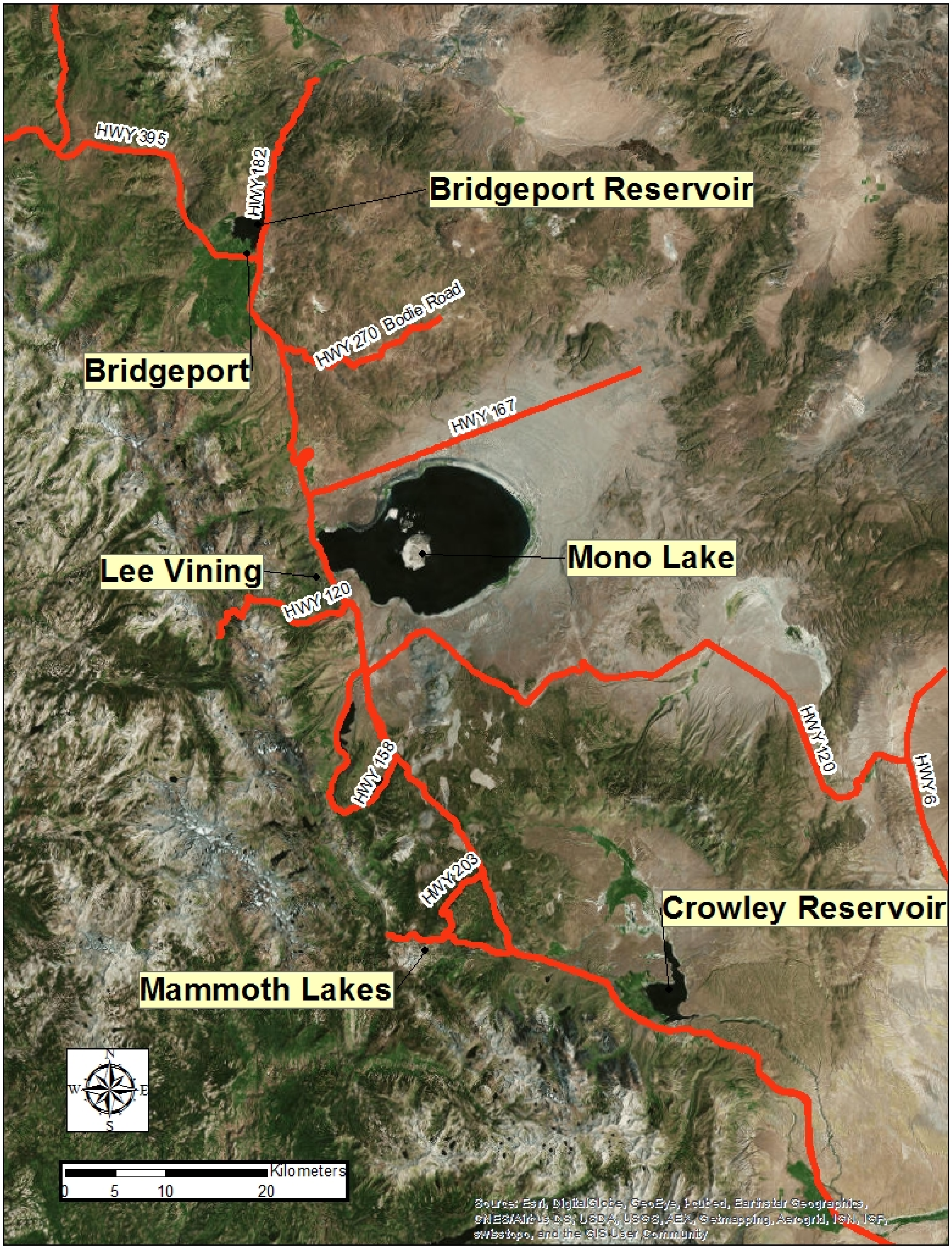

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Figure 1. Lakes and Reservoirs Surveyed in 2015

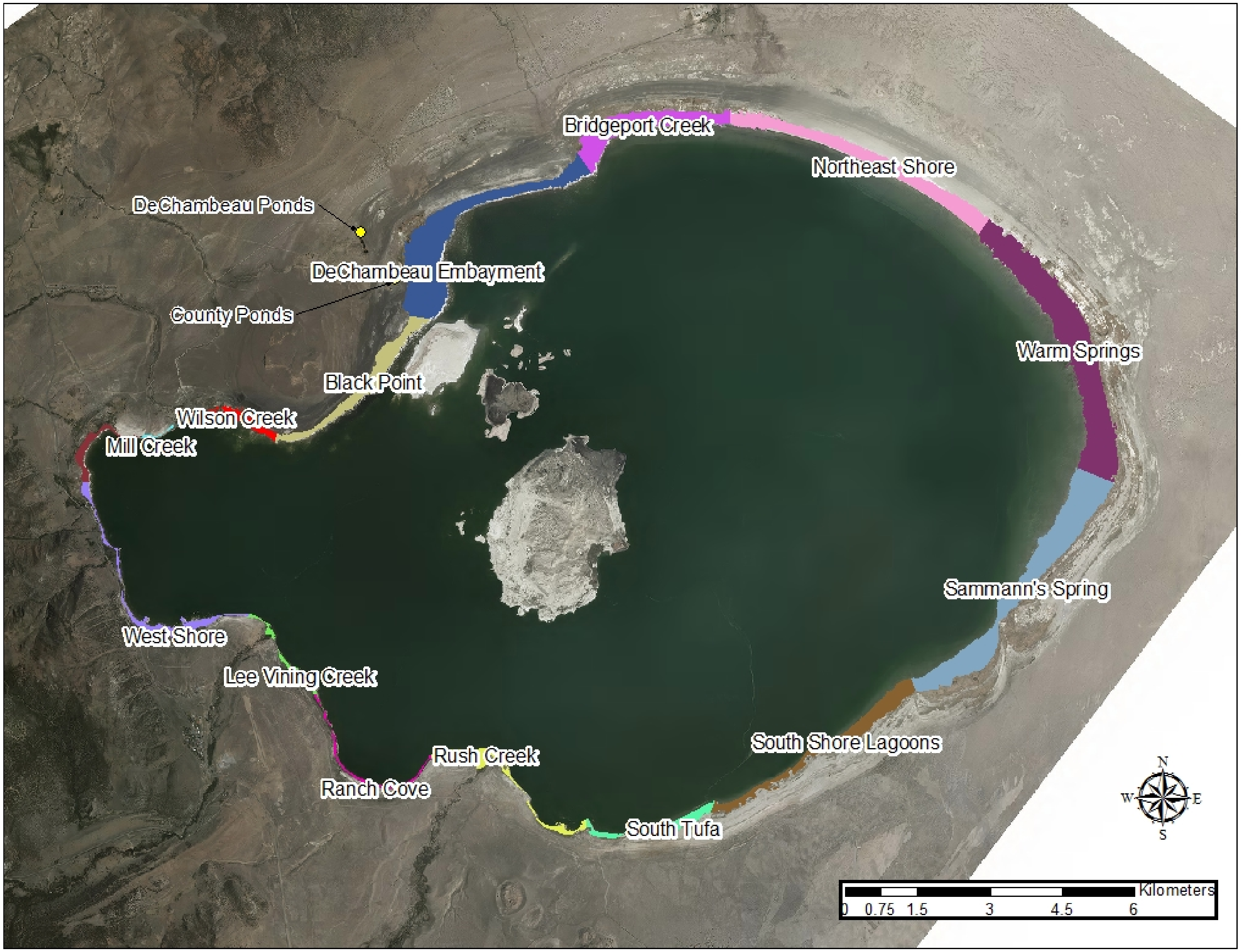

Figure 2. Mono Lake Lakeshore Segments

Figure 3. DeChambeau Creek Area

Figure 4. Mill Creek

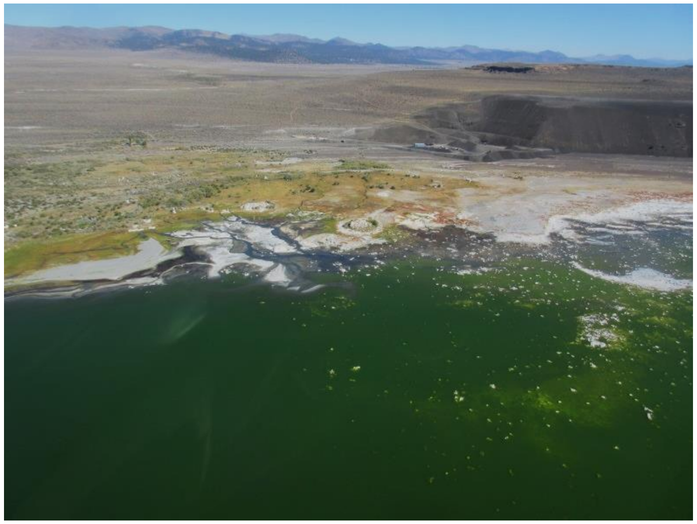

Figure 5. Wilson Creek

Figure 6. Black Point

Figure 7. – DeChambeau Embayment - Perseverence Spring

Figure 8. Bridgeport Creek

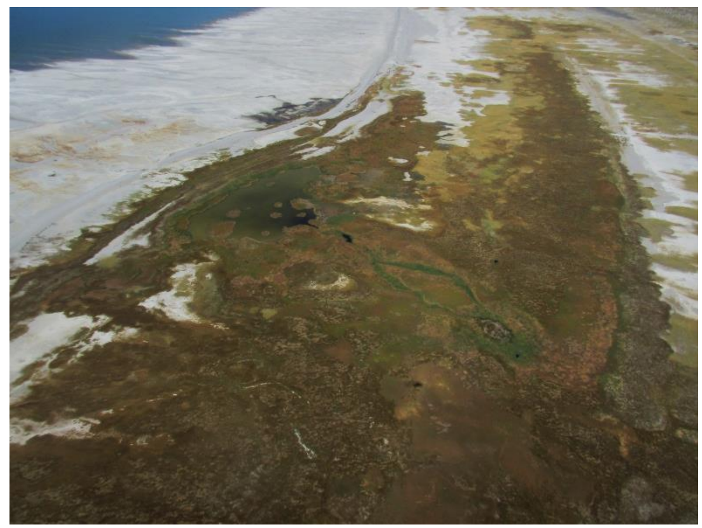

Figure 9. Northeast Shore

Figure 10. Warm Springs – North Pond

Figure 11. Sammann's Spring – west

Figure 12. Sammann's Spring east

Figure 13. South Shore Lagoons - Goose Springs

Figure 14. South Shore Lagoons - Sand Flat Spring

Figure 15. South Shore Lagoons

Figure 16. South Tufa Area

Figure 17. South Tufa – Navy Beach

Figure 18. Rush Creek delta

Figure 19. Ranch Cove

Figure 20. Lee Vining Creek Delta

Figure 21. West Shore

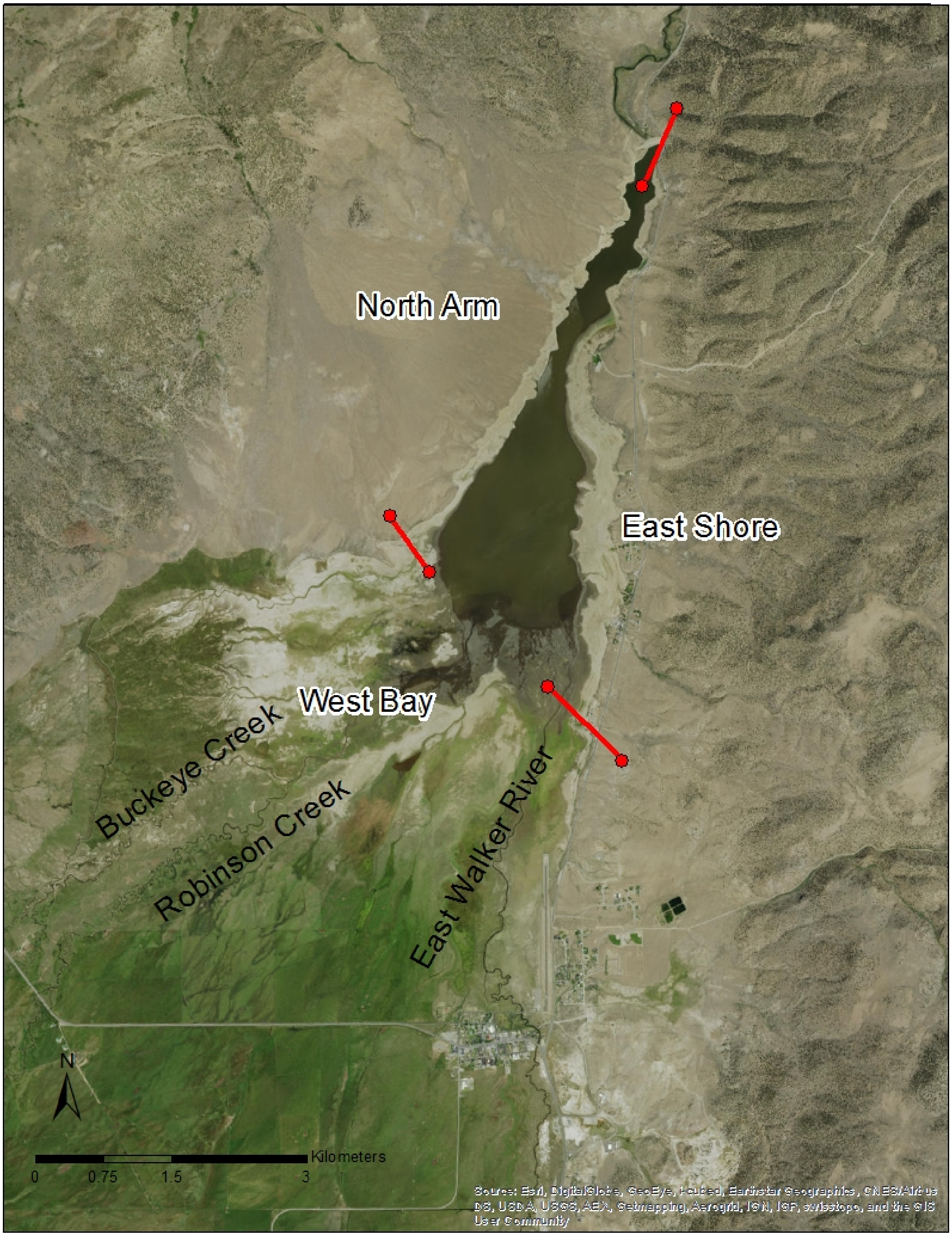

Figure 22. Bridgeport Reservoir Shoreline Segments

Figure 23. Photo of Bridgeport Reservoir, Looking North
Photo shows the West Bay area and the south end of the East Shore area. The majority of waterfowl that use Bridgeport Reservoir in the fall congregate in this southern end of the reservoir.

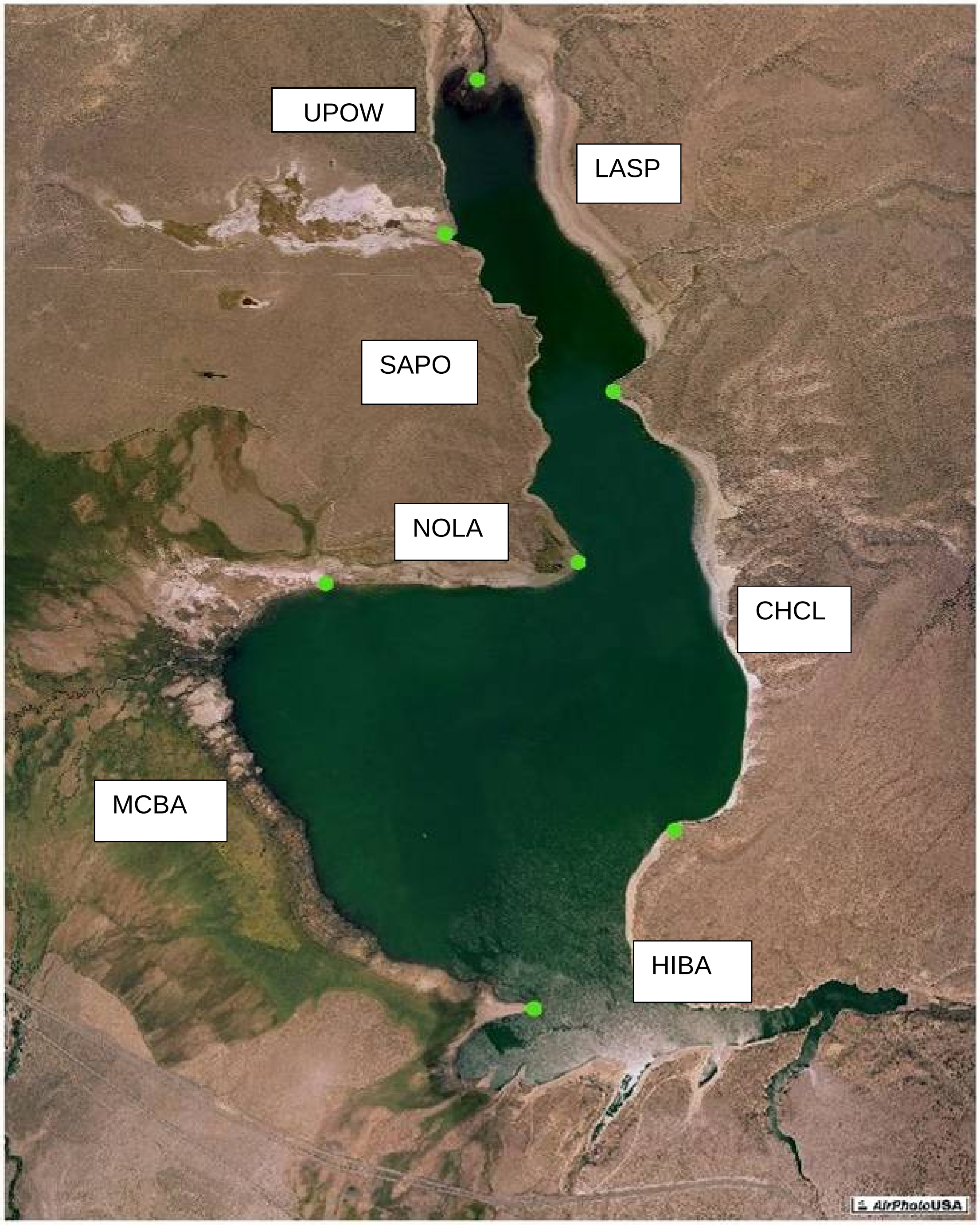

Figure 24. Crowley Reservoir Shoreline Segment Areas

Figure 25. Crowley- Upper Owens River Delta

Figure 26. Crowley -Sandy Point Shoreline Area

Figure 27. Crowley - North Landing Shoreline Area

Figure 28. Crowley - McGee Bay

Figure 29. Crowley -Hilton Bay

Figure 30. Crowley - Chalk Cliffs

Figure 31. Crowley - Layton Springs

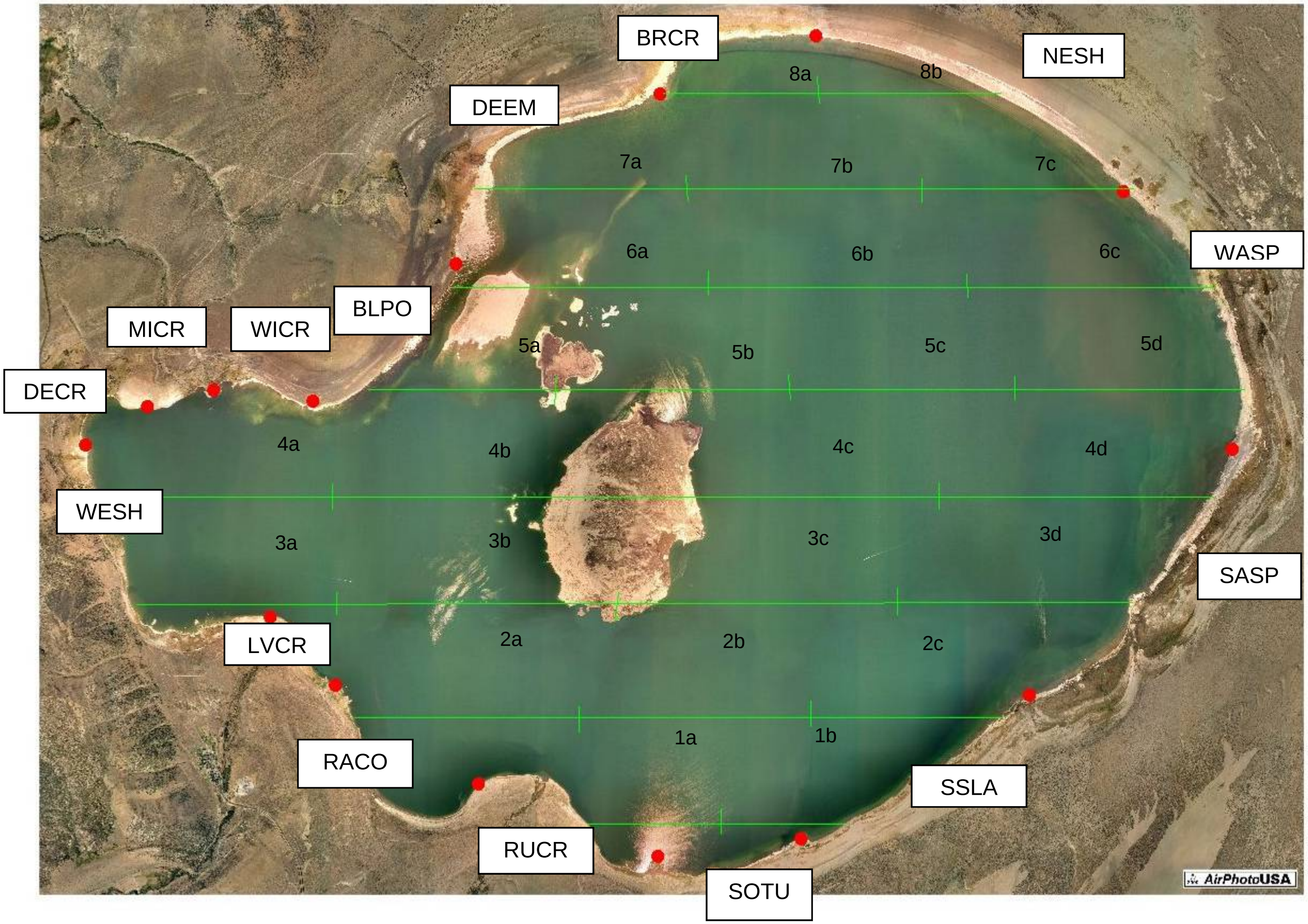

Figure 32. Mono Lake Fall Aerial Survey Cross-lake Transects and Shoreline Segments

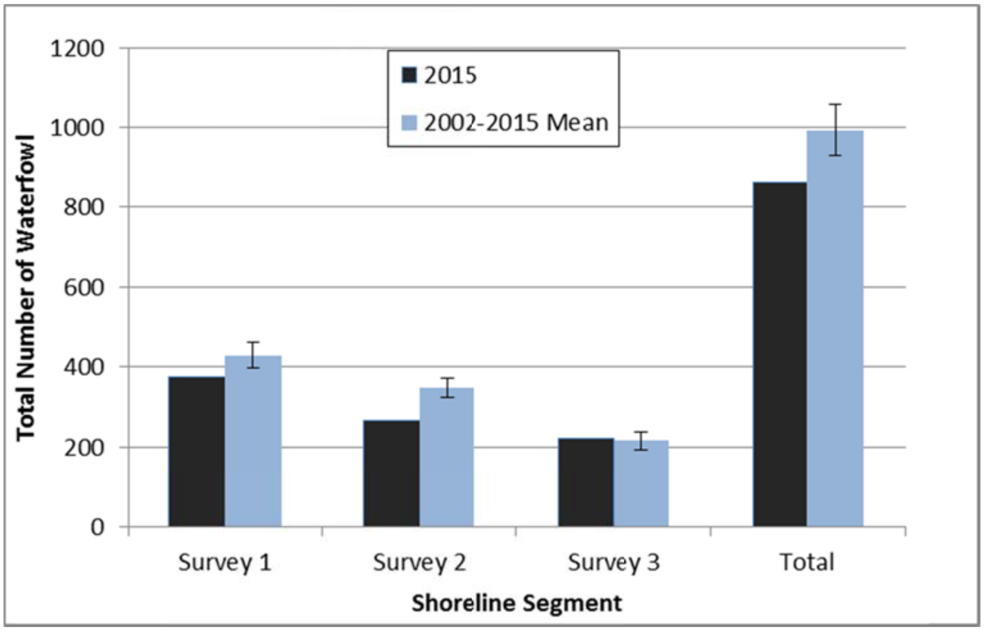

Figure 33. Mono Lake Summer Surveys – Total Waterfowl per Survey 2015 and 2002-2015 Mean. Error Bars Represent Standard Error of the Mean for 2002-2015.

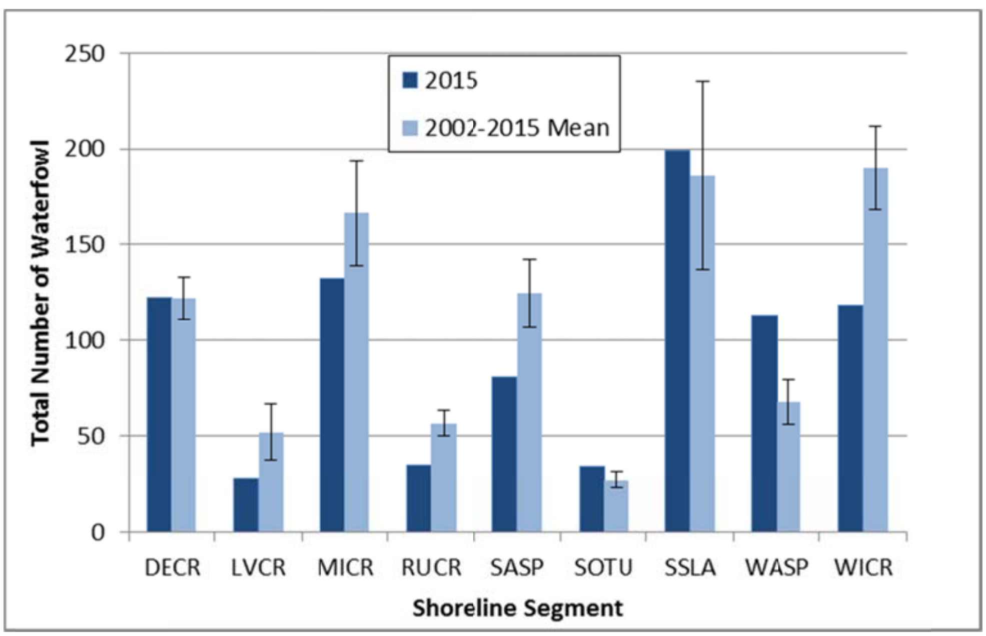

Figure 34. Spatial distribution of waterfowl during summer surveys 2015 and 2002-2015. Error Bars Represent Standard Error of the Mean for 2002-2015.

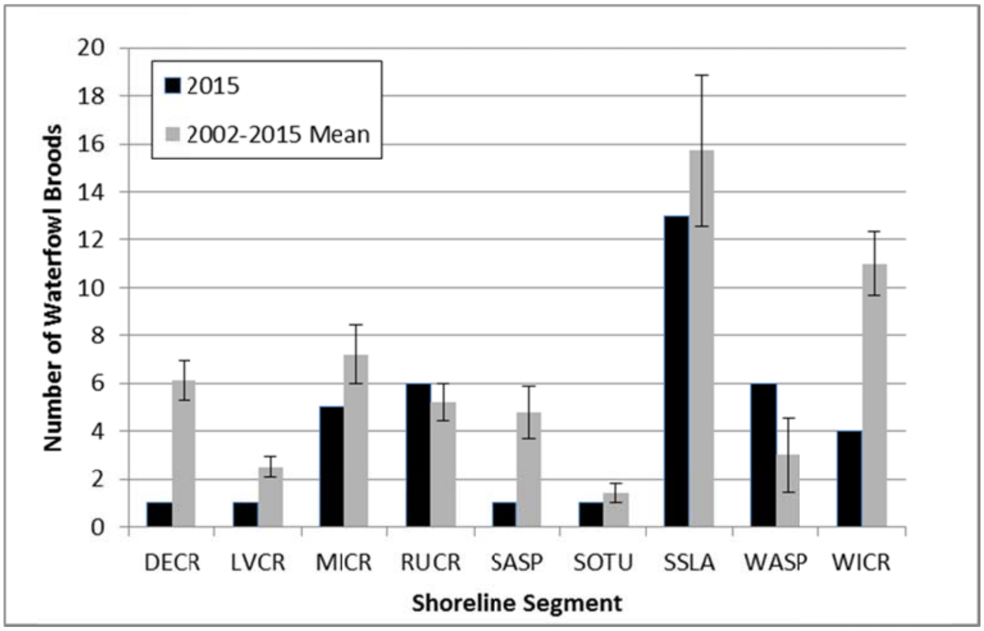

Figure 35.
Spatial distribution of observed waterfowl broods during summer surveys 2015 and 2002-2015. Error Bars Represent Standard Error of the Mean for 2002-2015.

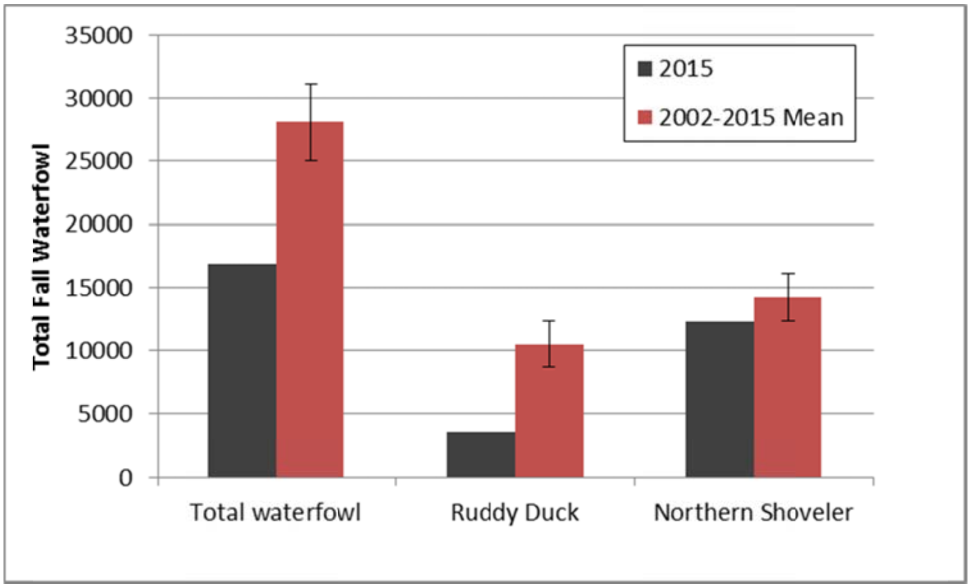

Figure 36. A comparison of fall counts of all waterfowl and numbers of Ruddy Duck and Northern Shoveler at Mono Lake 2015 vs. 2002-2015 long-term mean. Error Bars Represent Standard Error of the Mean for 2002-2015.

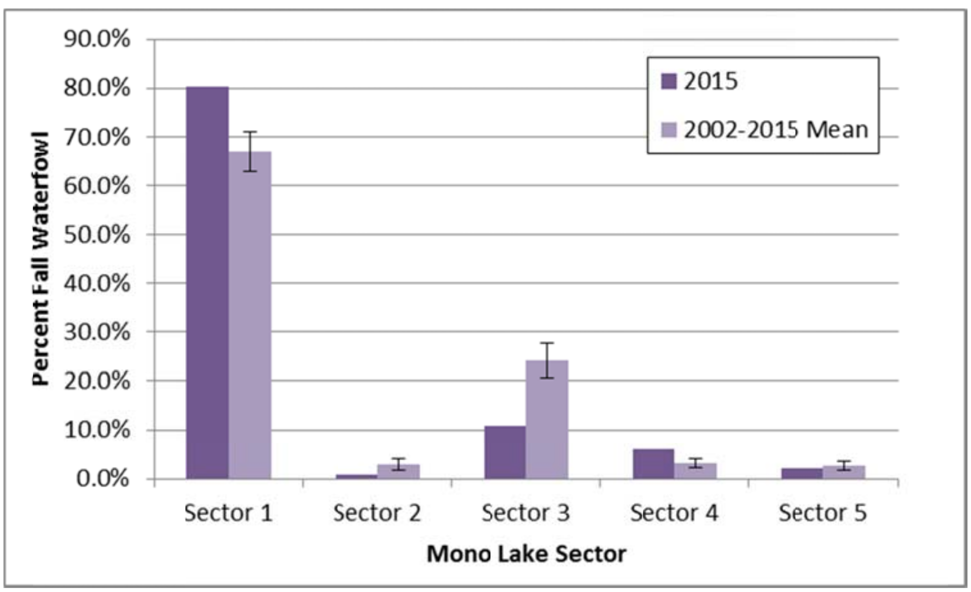

Figure 37. Spatial distribution of waterfowl at Mono Lake by sector 2015 vs. 2002-2015 long-term mean. Error Bars Represent Standard Error of the Mean for 2002-2015.

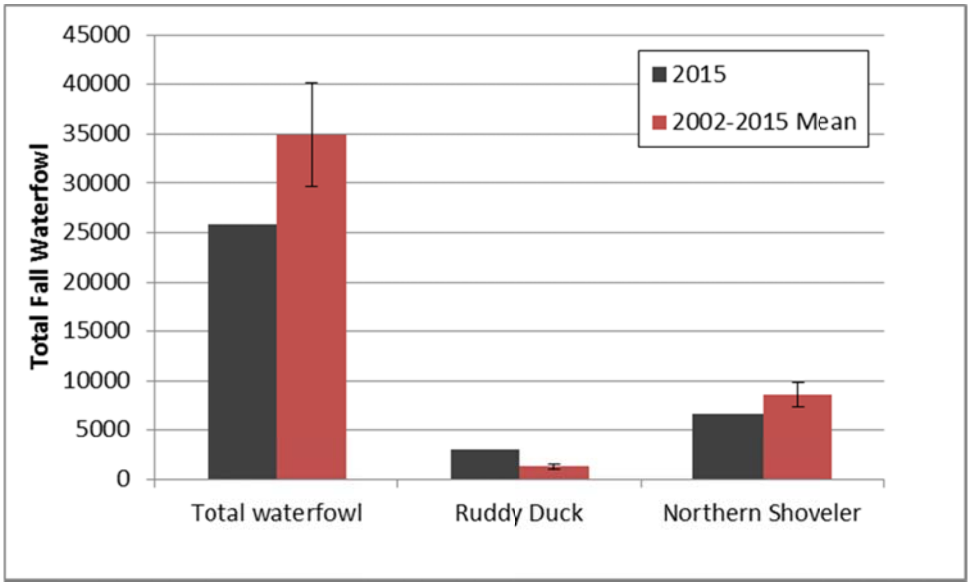

Figure 38. A comparison of fall counts of all waterfowl and numbers of Ruddy Duck and Northern Shoveler at Bridgeport Reservoir 2015 vs. 2002-2015 long-term mean. Error Bars Represent Standard Error of the Mean for 2002-2015.

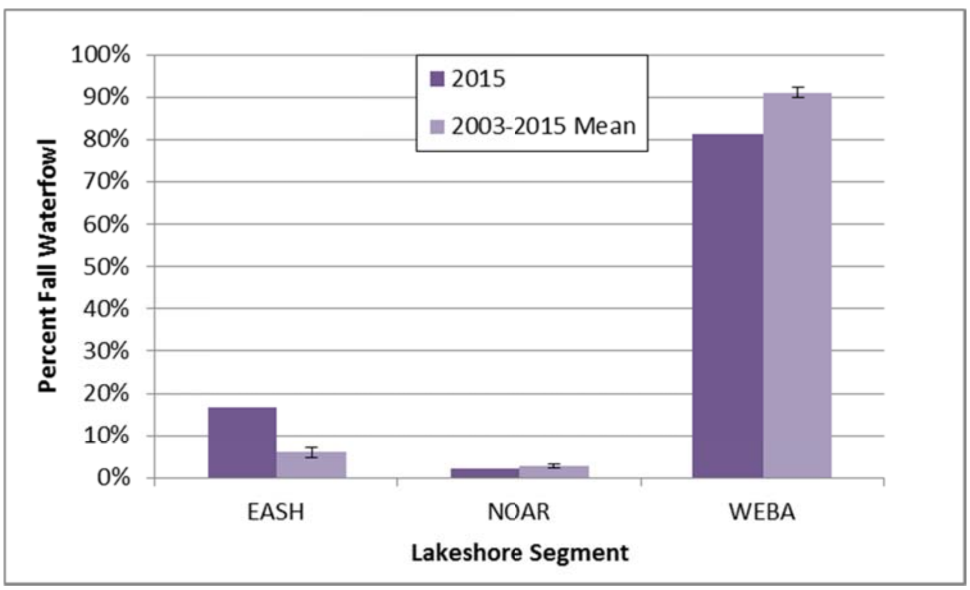

Figure 39. Spatial distribution of waterfowl at Bridgeport Reservoir by lakeshore segment 2015 vs. 2002-2015 long-term mean. Error Bars Represent Standard Error of the Mean for 2002-2015.

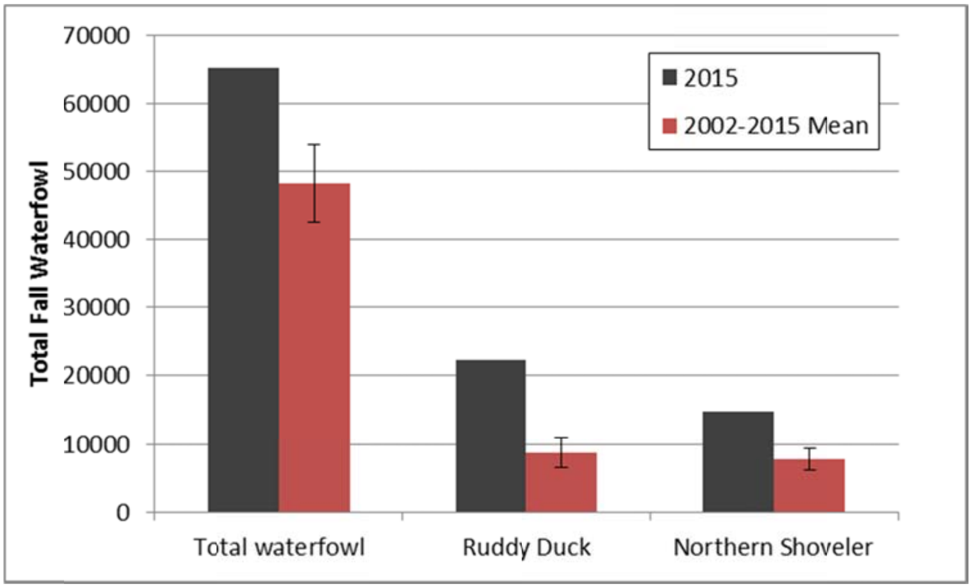

Figure 40. A comparison of fall counts of all waterfowl and numbers of Ruddy Duck and Northern Shoveler at Crowley Reservoir 2015 vs. 2002-2015 long-term mean. Error Bars Represent Standard Error of the Mean for 2002-2015.

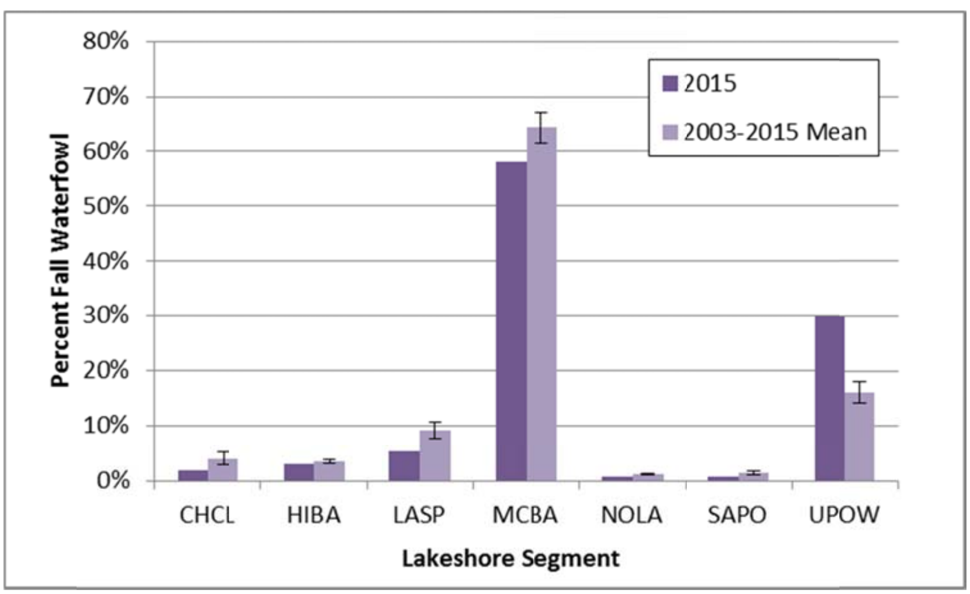

Figure 41. Spatial distribution of waterfowl at Crowley Reservoir by lakeshore segment 2015 vs. 2002-2015 long-term mean. Error Bars Represent Standard Error of the Mean for 2002-2015.

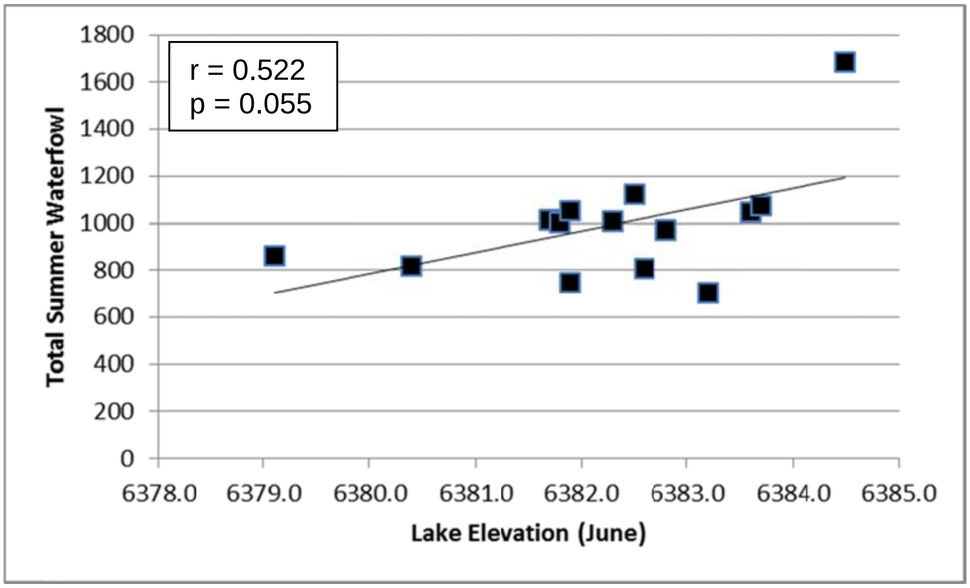

Figure 42. Relationship between total summer waterfowl and Mono Lake elevation in June

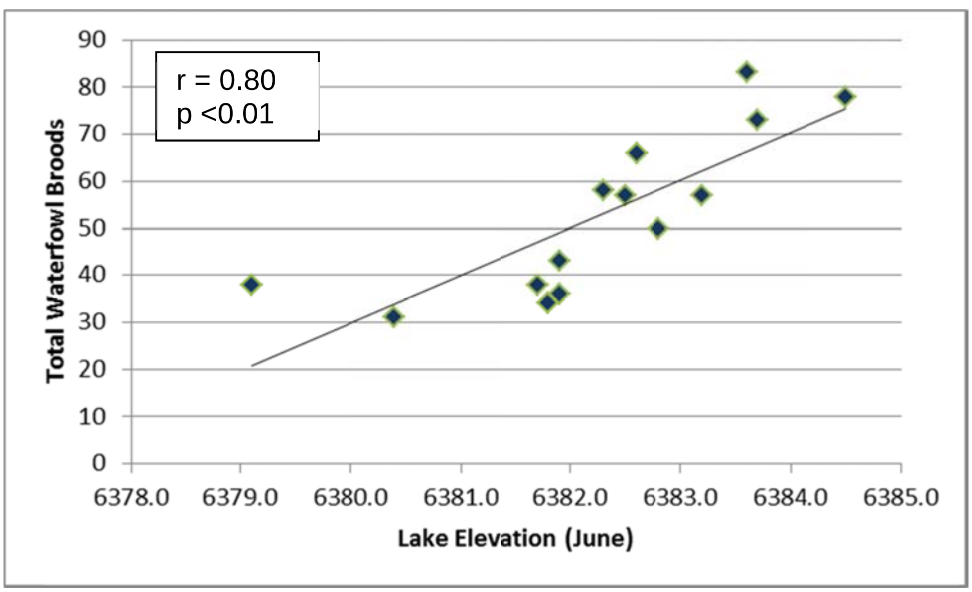

Figure 43. Relationship between number of waterfowl broods at Mono Lake elevation in June

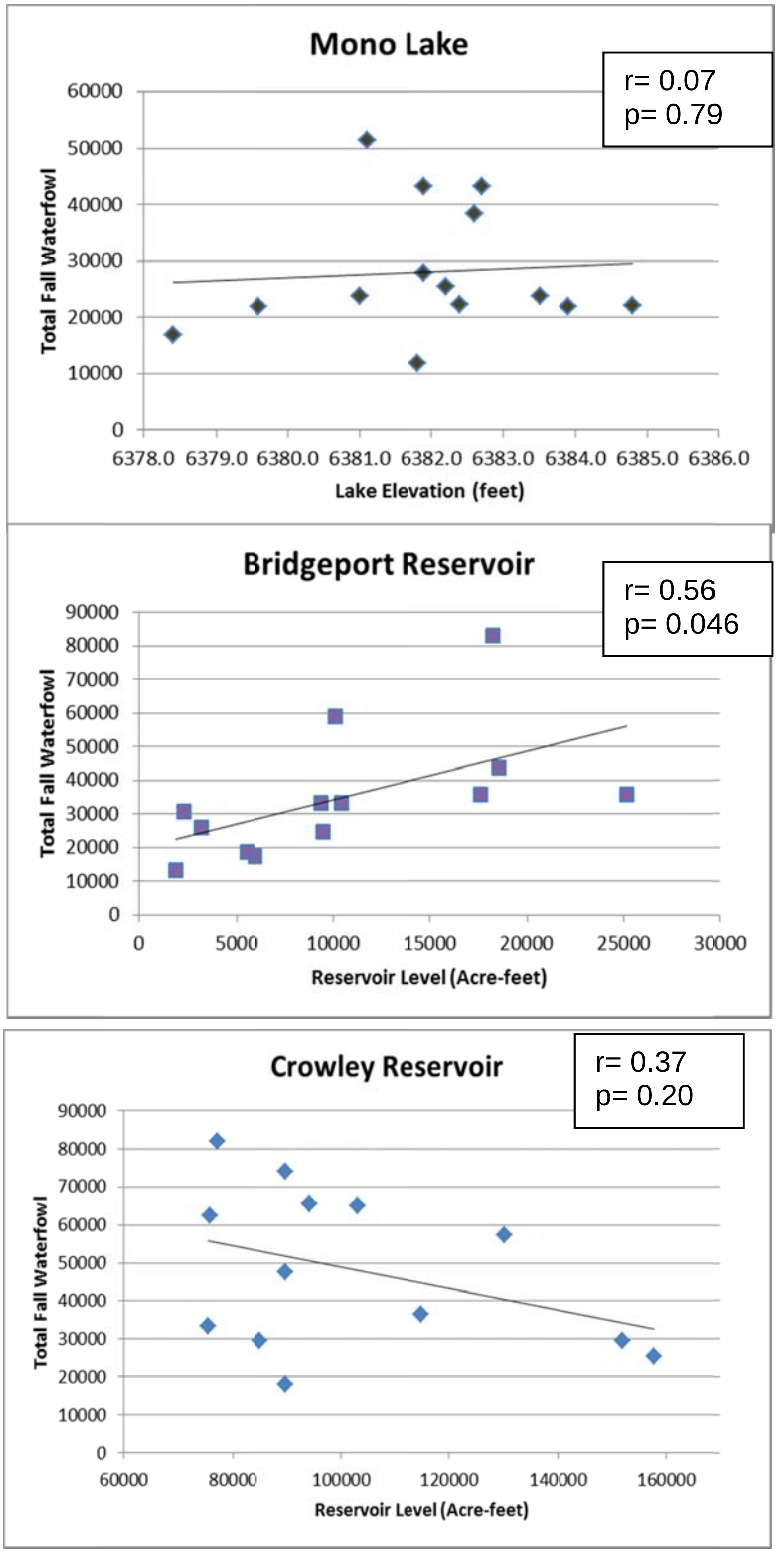

Figure 44. Relationship between total fall waterfowl and lake elevation at all three survey areas

APPENDICES

Appendix 1. Habitat Categories Used for Documenting Use by Waterfowl Species

(from Mono Lake Landtype Inventory, 2014 Conditions, LADWP 2014).

Marsh: Saturated and permanently flooded habitat dominated by obligate hydrophytic plant species. Prominent species include hard-stem bulrush (*Schoenoplectus acutus*), cattail (*Typha latifolia*), and three square (*Schoenoplectus americanus*). Marsh occurs in association with semi-permanently flooded wet meadow, seasonally flooded alkali wet meadow, and dry meadow/forb landtypes.

Wet Meadow: Semi-permanently flooded habitat dominated by obligate and facultative wetland plant species. Prominent species include rushes (*Juncus* spp.), spikerushes (*Eleocharis* spp.), saltgrass (*Distichlis spicata*) and sedges (*Carex* spp.). Wet meadow occurs in association with marsh, alkali wet meadow, and dry meadow/forb landtypes.

Alkali Wet Meadow: Seasonally flooded habitat and areas with high water table dominated by facultative wetland plant species. Prominent species include saltgrass (*Distichlis spicata*) and Baltic rush (*Juncus arcticus*) with nearly total canopy cover. Alkali wet meadow occurs in association with marsh, wet meadow and dry meadow/forb.

Dry Meadow/Forb: Relatively dry habitat dominated by facultative wetland and facultative upland plant species.

Riparian shrub: Seasonally flooded areas dominated hydrophytic shrubs. Prominent plants include willow (*Salix* spp.), buffalo berry (*Shepardia argentea*) and Wood's rose (*Rosa woodsii*).

Riparian Woodland: Typically transitional from seasonally flooded riparian towards moist upland. Aspen (*Populus tremuloides*), and black cottonwood (*Populus balsamifera*) are typically prominent; Jeffrey pine (*Pinus jeffreyi*) is often present. Riparian woodland is prominent along Lee Vining Creek.

Great Basin scrub: Upland scrub dominated by sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata*) with scant understory. Occurs primarily on the upslope margin of the lake bed on terrace.

Rabbitbrush scrub: Upland scrub dominated by rabbitbrush (*Ericameria nauseosa*) with scant understory. Most areas of rabbitbrush were previously mapped as *unvegetated* or *Great Basin scrub*. Rabbitbrush occurs in association with barren lake bed and dry meadow/forb.

Eolian deposit: Low dunes and sand sheets, typically with a sparse scrub canopy and sparse saltgrass understory. It occurs in association with barren lake bed. It was included as *Great Basin scrub* or *unvegetated* in previous mapping

Unvegetated: Mostly barren lake bed, but also includes streambars near the mouths of streams. Unvegetated area increased between 1999 and 2009, mostly in response to declining lake elevation exposing barren lake bed. Prior to 2014, unvegetated areas included large areas of rabbitbrush scrub. The 2014 decline in unvegetated is mostly partly a response to delineating 1,913 acres of rabbitbrush scrub on the lake bed.

Freshwater Stream: Tributary streams flowing to Mono Lake. Includes lowest portions of Rush, Lee Vining, Dechambeau, Mill, and Wilson Creeks not shrouded by vegetation that are discernible on imagery.

Freshwater Pond: Ponds fed by springs within marsh areas or artificially with stream diversions (*e.g*. DeChambeau/County ponds).

Freshwater Ria: Surface water at the mouths of streams that likely has some salt/fresh water stratification. Only a few rias totaling less than 3 acres were identified in 1999, 2005 and 2009; but 72 areas totaling 39 acres were identified in 2014, including many small areas with direct connection to Mono Lake. Freshwater rias may not have been delineated consistently in 2014; they could not be spectrally distinguished from ephemeral brackish lagoon or hypersaline lagoon.

Ephemeral Brackish Ponds: Ponds separated from Mono Lake by littoral bars that receive drainage from upslope marsh and wet meadow sustained by springs. The area of this type decreased from 109 acres in 1999 to less than 15 acres in subsequent years. These features were not delineated consistently in 2014; they could not be spectrally distinguished from ria or ephemeral hypersaline pond.

Ephemeral Hypersaline Pond: Ponds separated from Mono Lake by littoral bars that appear to lack a freshwater source. These areas contain concentrated brine due to evaporation. The area of this type decreased from 111 acres in 1999 to 24 acres in 2005. It comprised less than an acre in 2009 and 2014. These features were not mapped consistently in 2014; they could not be distinguished from ria or ephemeral brackish pond.

Mud flat: Wet substrate, shallow water, and algae within recent drawdown zone along the lake margin. About 15 acres of this type was identified in 2014. Again, in was mapped somewhat inconsistently.

Appendix 2. Lakeshore Segment Boundaries
(UTM, Zone 11, NAD 27, CONUS)

Mono Lake	Lakeshore Segment	Code	Easting	Northing
	South Tufa	SOTU	321827	4201363
	South Shore Lagoons	SSLA	324470	4201876
	Sammann's Spring	SASP	328552	4204369
	Warm Springs	WASP	332240	4208707
	Northeast Shore	NESH	330050	4213640
	Bridgeport Creek	BRCR	324787	4216042
	DeChambeau Embayment	DEEM	321835	4215037
	Black Point	BLPT	318172	4211968
	Wilson Creek	WICR	315378	4209451
	Mill Creek	MICR	313690	4209742
	DeChambeau Creek	DECR	312630	4209468
	West Shore	WESH	311454	4208509
	Lee Vining Creek	LVCR	314833	4205764
	Ranch Cove	RACO	316216	4204134
	Rush Creek	RUCR	318624	4202827
Crowley Reservoir				
	Upper Owens	UPOW	346943	4167342
	Sandy Point	SAPO	345949	4167138
	North Landing	NOLA	346911	4164577
	McGee Bay	MCBA	344988	4164675
	Hilton Bay	HIBA	346329	4161198
	Chalk Cliff	CHCL	347613	4162620
	Layton Springs	LASP	347152	4165944
Bridgeport Reservoir				
	North Arm	NOAR	306583	4244288
	West Bay	WEBA	304353	4240954
	East Shore	EASH	305814	4239412

Appendix 3. 2015 Ground Count Survey Dates and Times

Survey 1

Survey Area	Survey Date and Time			
	8-Jun	9-Jun	10-Jun	11-Jun
RUCR	0548 - 0720 hrs			
SOTU	0812-0954 hrs			
SSLA	0954 - 1256 hrs			
DECR			0537 - 0636 hrs	
MICR			0637 - 0723 hrs	
WICR			0723 - 0756 hrs	
LVCR			0933 - 1040 hrs	
DEPO		1300-1316 hrs		
COPO		1245-1258 hrs		
SASP		0635 - 0945 hrs		
WASP				0700 - 1130 hrs

Survey 2

Survey Area	Survey Date and Time			
	29-Jun	30-Jun	1-Jul	2-Jul
RUCR	1242 - 1500 hrs			
SOTU	0554 - 0705 hrs			
SSLA	0705 - 1000 hrs			
DECR		0537 - 0635 hrs		
MICR		0636 - 0738 hrs		
WICR		0739 - 0835 hrs		
LVCR		1140 - 1210 hrs		
DEPO		1045 - 1105 hrs		
COPO		1025 - 1039 hrs		
SASP			0605 - 0810 hrs	
WASP				0700 - 0840 hrs

Survey 3

Survey Area	Survey Date and Time				
	20-Jul	21-Jul	22-Jul	23-Jul	24-Jul
RUCR	0556 - 0739 hrs				
SOTU	1010 - 1110 hrs				
SSLA		0702 - 1033 hrs			
DECR			0550 - 0655 hrs		
MICR			0655 - 0817 hrs		
WICR			0817 - 0900 hrs		
LVCR	0820 - 0925 hrs				
DEPO	1326 - 1335 hrs				
COPO	1305 - 1323 hrs				
SASP					0630 - 0923 hrs
WASP				0643 - 1130 hrs	

Appendix 4. 2015 Fall Aerial Survey Dates

Survey Number	1	2	3	4	5	6
Mono Lake	2-Sep	17-Sep	2-Oct	13-Oct	30-Oct	12-Nov
Bridgeport Reservoir	2-Sep	17-Sep	2-Oct	13-Oct	30-Oct	12-Nov
Crowley Reservoir	2-Sep	17-Sep	2-Oct	13-Oct	30-Oct	12-Nov

Appendix 5. Mono Lake Cross-Lake Transect Positions

Cross-Lake Transect Number	Latitude
1	37º 57’00”
2	37º 58’00”
3	37º 59’00”
4	38º 00’00”
5	38º 01’00”
6	38º 02’00”
7	38º 03’00”
8	38º 04’00”

Appendix 6. Common and Scientific Names for Species Referenced in the Document.

Common Name	Scientific Name
Greater White-fronted Goose	*Anser albifrons*
Snow Goose	*Chen caerulescens*
Cackling Goose	*Branta hutchinsii*
Canada Goose	*Branta canadensis*
Tundra Swan	*Cygnus columbianus*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Mallard	*Anas platyrhynchos*
Blue-winged Teal	*Anas discors*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Northern Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
Unidentified Teal	*Anas* (spp.)
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Lesser Scaup	*Aythya affinis*
Bufflehead	*Bucephala albeola*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*Mergus serrator*
Ruddy Duck	*Oxyura jamaicensis*

2015 Annual Report

Mono Lake Limnology Monitoring

Prepared by:

Matthew Kerby

Watershed Resources Specialist

Los Angeles Department of Water and Power

Bishop, CA.

Prepared for: State Water Resources Control Board

March 2016

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INTRODUCTION

Limnological monitoring was conducted in 2015 at Mono Lake as required under the State Water Resources Control Board Order No. 98-05. The limnological monitoring program at Mono Lake is one component of the Mono Basin Waterfowl Habitat Restoration Plan (LADWP, 1996). The purpose of the limnological monitoring program as it relates to waterfowl is to assess limnological and biological factors that may influence waterfowl use of lake habitat (LADWP 1996). The limnological monitoring program consists of four components: meteorological, physical/chemical, phytoplankton, and brine shrimp population data.

An intensive limnological monitoring of Mono Lake has been funded by Los Angeles Department of Water and Power (LADWP) since 1982. The Marine Science Institute (MSI), University of California, Santa Barbara served as the principle investigator, and Sierra Nevada Aquatic Research Laboratory (SNARL) provided field sampling and laboratory analysis technicians until July 2012. After receiving training in limnological sampling and laboratory analysis methods from the scientists and staff at MSI and SNARL, LADWP Watershed Resources Staff assumed responsibility for the program, and has been conducting limnological monitoring of Mono Lake since July of 2012.

This report summarizes monthly field sampling for the year of 2015. Laboratory support including the analysis of ammonium and chlorophyll *a* in 2015 was provided by Environmental Science Associates (ESA), Davis, California.

METHODS

Methodologies for both field sampling and laboratory analysis followed those specified in *Field and Laboratory Protocols for Mono Lake Limnological Monitoring (Field and Laboratory Protocols)* (Jellison 2011). The methods described in *Field and Laboratory Protocols* are specific to the chemical and physical properties of Mono Lake and therefore may vary from standard limnological methods (e.g. Strickland and Parsons 1972). The methods and equipment used by LADWP to conduct limnological monitoring was consistent and followed those identified in *Field and Laboratory Protocols* except where noted below.

Meteorology

One meteorological station on Paoha Island provided weather data in 2015. The Paoha Island measuring station is located approximately 30 m from shore on the southern tip of the island.

The base of the station is at 1,948m above sea level, several meters above the current surface elevation of the lake. Sensor readings are made every second and stored as either ten-minute averages or hourly values in a Campbell Scientific CR 1000 datalogger. Data are downloaded to a storage module which is collected periodically during field sampling visits.

At the Paoha Island station, wind speed and direction (RM Young wind monitor) are measured by sensors at a height of 3m above the surface of the island and are averaged over a 10-minute interval. During the 10-minute interval, maximum wind speed is also recorded. Using wind speed and direction measurements, the 10-minute wind vector magnitude and wind vector direction are calculated. Hourly measurements of photosynthetically available radiation (PAR, 400 to 700nm, Li-Cor 192-s), 10-minute averages of relative humidity and air temperature (Vaisalia HMP35C), and total rainfall (Campbell Scientific TE525MM-L tipping bucket) are also stored. The minimum detection limit for the tipping bucket gage is 1mm of water. The tipping bucket is not heated therefore the instrument is less accurate during periods of freezing due to sublimation of ice and snow.

The daily mean wind speed, maximum mean wind speed, and relative humidity were calculated from 10-minute averaged data from the Paoha Island site.

Field Sampling

Sampling of the physical, chemical and biological properties of the water including the *Artemia* community was conducted at 12 buoyed stations at Mono Lake (Figure 1). The water depth at each station at a lake elevation of 1,946m is indicated on Figure 1. Stations 1-6 are considered western sector stations, and stations 7-12 are eastern sector stations. Surveys were generally conducted around the 15th of each month.

Physical and Chemical

Sampling of the physical and chemical properties included lake transparency, water temperature, conductivity, dissolved oxygen, and nutrients (ammonium). Lake elevation data was obtained directly from the LADWP database records. Annual lake elevation for year to year comparison was calculated based on average April (water year) daily measurements. Lake transparency was measured at all 12 stations using a Secchi disk. A high-precision conductivity temperature-depth (CTD) profiler was used to record conductivity at nine stations (2, 3, 4, 5, 6, 7, 8, 10 and 12). The former CTD unit had issues with inconsistent battery power during the first five months of the sampling year. Therefore, conductivity is not reported for the months of February through May. A new high-precision conductivity temperature-depth (CTD) profiler (Seabird 19 plus V2) was purchased and implemented beginning during the June survey and has replaced the Idronaut CTD instrument which has been unreliable. During sampling, the Seabird CTD was initially lowered just below the surface of the water for 40 seconds during the pump delay time. The CTD was then lowered at a rate of ~0.5 meters/second with data collected at approximately 12.5 centimeter depth intervals. The Seabird CTD is programmed to collect data at 250 millisecond intervals. Both CTD meters were used to collect data for the months June and July and compared for consistency.

Dissolved oxygen was measured at one centrally located station (Station 6). Dissolved oxygen concentration was measured with a Yellow Springs Instruments Rapid Pulse Dissolved Oxygen Sensor (YSI model 6562). Readings were taken at one-meter intervals and at 0.5 meter intervals in the vicinity of the oxycline and other regions of rapid change. Data are reported for one-meter intervals only.

Monitoring of ammonium in the epilimnion was conducted using a 9-m integrated sampler at stations 1, 2, 5, 6, 7, 8, and 11. An ammonium profile was developed by sampling at station 6 from eight discrete depths (2, 8, 12, 16, 20, 24, 28, and 35 meters) using a vertical Van Dorn sampler. Samples for ammonium analyses were filtered through Gelman A/E glass-fiber filters and following collection, immediately placed onto dry ice and frozen in order to stabilize the ammonium content (Marvin and Proctor, 1965). Ammonium samples were transported on dry ice back to the laboratory transfer station. The ammonium samples were stored frozen until delivered to the University of California Davis Analytical Laboratory (UCDAL) located in Davis, California. Samples were stored frozen until analysis. The lower detection limit for ammonium was 2.8 µg/L.

Phytoplankton

<u>*Chlorophyll a* sampling</u>

Monitoring of chlorophyll *a* in the epilimnion was conducted using a 9-m integrated sampler at stations 1, 2, 5, 6, 7, 8, and 11. A chlorophyll profile was developed by sampling at station 6 from seven discrete depths (2, 8, 12, 16, 20, 24, and 28 meters) using a vertical Van Dorn sampler. Water samples were filtered into opaque bottles through a 120 µm sieve to remove all life stages of *Artemia*. Chlorophyll *a* samples were kept cold and transported on ice back to the laboratory transfer station located in Sacramento, CA.

Brine Shrimp

<u>*Artemia* sampling</u>

The *Artemia* population was sampled by one vertical net tow from each of twelve stations (Figure 1). Samples were taken with a plankton net (0.91 m x 0.30 m diameter, 118 µm Nitex mesh) towed vertically through the water column. Samples were preserved with 5% formalin in Mono Lake water. When mature females were present, an additional net tow was taken from four western sector stations (1, 2, 5 and 6) and three eastern sector stations (7, 8 and 11) to collect adult females for fecundity analysis including body length and brood size. Live females collected for fecundity analysis were kept cool and in low densities during transport to the LADWP laboratory in Bishop, CA.

Laboratory Analysis

Ammonium

Starting in August 2012, the methodology used by UCDAL for ammonium was flow injection analysis. In July 2012, this method was tested on high salinity Mono Lake water and was found to give results comparable to previous years. This method has detection limits of approximately 2.8 µM. Immediately prior to analysis, frozen samples were allowed to thaw and equilibrate to room temperature, and were shaken briefly to homogenize. Samples were heated with salicylate and hypochlorite in an alkaline phosphate buffer (APHA 1998a, APHA 199b, Hofer 2003, Knepel 2003). EDTA (Ethylenediaminetetraacetic acid) was added in order to prevent precipitation of calcium and magnesium, and sodium nitroprusside was added in order to enhance sensitivity. Absorbance of the reaction product was measured at 660 nm using a Lachat Flow Injection Analyzer (FIA), QuikChem 8000, equipped with a heater module. Absorbance at 660 nm is directly proportional to the original concentration of ammonium, and ammonium concentrations were calculated based on absorbance in relation to a standard solution.

Chlorophyll a

The determination of chlorophyll *a* was done by fluorometric analysis following acetone extraction. Fluorometry was chosen, as opposed to spectrophotometry, due to higher sensitivity of the fluorometric analysis, and because data on chlorophyll *b* and other chlorophyll pigments were not needed.

At the laboratory transfer station in Sacramento, water samples (200 mL) were filtered onto Whatman GF/F glass fiber filters (nominal pore size of 0.7 µm) under vacuum. Filter pads were then stored frozen until they could be overnight mailed, on dry ice, to the University of Maryland Center for Environmental Science Chesapeake Biological Laboratory (CBL), located in Solomons, Maryland. Sample filter pads were extracted in 90% acetone and then refrigerated in the dark for 2 to 24 hours. Following refrigeration, the samples were allowed to warm to room temperature, and then centrifuged to separate the sample material from the extract. The extract for each sample was then analyzed on a fluorometer. Chlorophyll *a* concentrations were calculated based on output from the fluorometer. Throughout the process, exposure of the samples to light and heat was avoided.

The fluorometer used in support of this analysis was a Turner Designs TD700 fluorometer equipped with a daylight white lamp, 340-500 nm excitation filter and >665 nm emission filter, and a Turner Designs Trilogy fluorometer equipped with either the non-acid or the acid optical module.

Artemia Population Analysis and Biomass

An 8x to 32x stereo microscope was used for all *Artemia* analyses. Depending on the density of shrimp, counts were made of the entire sample or of a subsample made with a Folsom plankton splitter. When shrimp densities in the net tows were high, samples were split so that approximately 100-200 individuals were subsampled. Shrimp were classified as nauplii (instars 1-7), juveniles (instars 8-11), or adults (instars >12), according to Heath's classification (Heath, 1924). Adults were sexed and the reproductive status of adult females was determined. Non-reproductive (non-ovigerous) females were classified as empty. Ovigerous females were classified as undifferentiated (eggs in early stage of development), oviparous (carrying cysts) or ovoviviparous (naupliar eggs present).

An instar analysis was conducted at seven of the twelve stations (Stations 1,2,5,6,7,8, and 11). Nauplii at these seven stations were further classified as to specific instar stage (1-7). Biomass was determined from the dried weight of the shrimp tows at each station. After counting, samples were rinsed with tap water and dried in aluminum tins at 50°C for at least 48 hours. Samples are weighed on an analytical balance immediately upon removal from the oven.

Artemia Fecundity

Immediately upon return to the laboratory, ten females from each sampled station were randomly selected, isolated into individual vials, and preserved with 5% formalin. Female length was measured at 8X from the tip of the head to the end of the caudal furca (setae not included). Egg type was noted as undifferentiated, cyst, or naupliar. Undifferentiated egg mass samples were discarded. Brood size was determined by counting the number of eggs in the ovisac and any eggs dropped in the vial. Egg shape was noted as round or indented.

Artemia Population Statistics

Calculation of long-term *Artemia* population statistics followed Jellison and Rose (2011). Daily values of adult *Artemia* between sampling dates were linearly interpolated in Microsoft Excel. The mean, median, peak and centroid day (calculated center of abundance of adults) were then calculated for the time period May 1 through November 30. Long-term values were determined by calculating the mean, minimum and maximum values for these parameters for the time period 1979-2015.

RESULTS

Meteorology

Wind Speed, relative humidity, air temperature and precipitation data from the weather station at Paoha Island are summarized monthly for 2015.

Wind Speed and Direction

Mean daily wind-speed varied from 1.2 to 15.6 m/sec with an overall mean for this time period of 3.2 m/sec (Figure 2). The daily maximum 10-min averaged wind speed (4.9 m/sec) on Paoha Island averaged 1.5 times the mean daily wind speed. The maximum recorded 10-min reading of 22.5 m/sec occurred on the afternoon of February 6th. As has been the case in previous years, winds were predominantly from the south (mean 187.6 degrees).

Air Temperature

Daily air temperatures as recorded at Paoha Island ranged from a low of -11.14°C on January 1 to a high of 32.5°C on June 26 (Figure 3). Winter temperature (January through February) ranged from -5.1°C to 9.9°C with an average maximum daily temperature of 3.3°C. The average maximum daily summer temperature (June through August) was 19.1°C.

Relative Humidity and Precipitation

The mean relative humidity for the period January 1st – December 31st, 2015 was 56% (Figure 4). Mean relative humidity was negatively correlated with both daily mean wind speed ($r = -0.339$, $p<0.001$, $n=365$), and maximum 10-minute mean wind speed ($r = -0.333$, $p<0.001$, $n=365$). The total precipitation measured at Paoha Island was 444.5 mm. In February precipitation was highest producing more than half the rainfall for the year (279 mm) with almost all the monthly rainfall (249 mm) occurring on February 6th (Figure 5). Spring months produced much less rain (36 mm) followed by summer months (28 mm). Fall precipitation increased to 43 mm and increased slightly in the month of December (58 mm). The greatest frequency of rain days (8) occurred in the month of May.

Physical and Chemical

Surface Elevation

The average surface elevation of Mono Lake in January 2015 was 6378.5 feet. A slight increase in elevation to 6378.7 feet was observed in March. Average elevation declined slightly (0.1 m) in April before reaching 6378.7 feet again in June. Starting in July lake elevation declined and continued through December. From the 2015 high of 6378.7 feet in June, the lake dropped a total of 1.1 feet to a low of 6377.6 feet by December. Figure 6 shows lake elevation from 1979 through 2015 and the mixing regime observed each year. As will be discussed below, Mono Lake continued to exhibit a monomictic mixing regime in 2015. For 2015 the greatest monthly change in surface elevation (0.4 feet) occurred in late summer from August to September.

Transparency

The lowest spring Secchi (average) depth was 0.41 m +/- 0.02 m in March (Table 1, Figure 7). As *Artemia* grazing reduced midsummer phytoplankton, lakewide transparency and Secchi depth increased through mid-July to a peak of 0.91 m +/- 0.01 m. Secchi depths began to decrease through the late summer and fall, and remained between 0.58 m and 0.46 m from

August through December. Overall Secchi depth transparency was reduced compared to last year. Average Secchi depth in July was lower (0.91 m) in 2015 compared to 2014 (1.5 m).

Water Temperature

The water temperature data from Station 6 indicate that Mono Lake remained monomictic in 2015 as the lake was thermally stratified from late spring to early fall with turnover occurring once later in the fall (Table 2, Figure 8). By early June the thermocline formed at 7-8 m (as indicated by the greater than 1°C change per meter depth) and fluctuated between 6 and 14 m through October. By mid-November temperatures were isothermic from 1 m to 40 m indicating the onset of holomixis (Table 2, Figure 8). Holomixis persisted throughout December as temperature data indicate little change with water temperatures between 5.4 and 5.5°C. Average water temperatures for the first four months of 2015 were warmer than 2014. The greatest difference in average temperature (4.8°C) between 2014 and 2015 was observed in July, followed by December (2.6°C).

Conductivity

Conductivity data was collected from the CTD field sampling device on a monthly basis. In situ conductivity measurements were corrected for temperature (25˚C) and reported at one meter intervals beginning at one meter in depth down to the lake bottom. Conductivity data is used to evaluate the salinity profile of the lake and are reported in Table 3. Data from February through May are not reported due to malfunction and subsequent replacement of the CTD probe. The winter of 2015 marked the fourth consecutive year of monomixis at Mono Lake. Mono Lake surface elevation slowly increased in the beginning of 2015 and reached its peak in March and persisted through June as freshwater inputs from snowmelt likely contributed to vertical salinity stratification. As thermal and chemical stratification became more prominent in the summer months the greatest difference between epilimnetic and hypolimnetic specific conductivities were reported in June (Table 3, Figure 9). Specific conductivities for June ranged from 84.8 to 88.9 mS/cm above 14 meters and from 89.0 to 89.8 mS/cm below 14 meters (Table 3).

By September average specific conductivity was only 1.8 mS/cm different between the epilimnion (87.0 mS/cm) and hypolimnion (88.8 mS/cm). In December conductivity was consistent throughout the water column measuring 91.4 mS/cm following the onset of complete holomixis in November.

Dissolved Oxygen

Dissolved oxygen (DO) levels at Station 6 were indicative of historical limnological mixing patterns observed at Mono Lake. In 2015 Mono Lake had one period of fall turnover marking the 4th continuous year of monomictic conditions. DO concentration in winter months within the first 15 m of the water column ranged as low as <1 mg/l in February below 6 m to as high as 10.7 mg/l at 2 m (Table 4, Figure 10*).* For comparison purposes the epilimnion refers to the first 15 m of the water column despite its movement from 7 m in early June to 14 m in October. Average epilimnetic DO levels were higher in spring months of March (5.6 mg/L) and April (3.4 mg/L) compared to early June (1.7 mg/L). Dissolved oxygen levels at Mono Lake are typically higher in spring months as phytoplankton blooms follow increased sunlight and temperature levels. In mid-June average DO levels in the first 6 m of the water column were about 7 times higher (5.2 mg/l) as 2014 levels (0.7 mg/l). DO levels near the lake substrate (39m) decreased from March to early June (1.1 to 0.4 mg/l) prior to full onset of meromixis. In early June, Mono Lake was thermally stratified with meromictic conditions persisting through October. In 2014 DO levels in the middle of summer (June - August) were unusually low (<1.1 mg/L) throughout the water column. In the summer of 2015 DO levels were higher than the previous year ranging from 0.9 to 6.0 mg/L in the epilimnion. In October the thermocline began to slowly breakdown prior to holomixis. In the fall average epilimnetic DO concentrations were highest in October (2.2 mg/l) followed by December (1.9 mg/l) and were lowest in November (1.7 mg/l) as monomolimnetic hypoxic waters began to mix with epilimnetic waters. (Table 4, Figure 10). Mono Lake remained monomictic in December.

Ammonium

Ammonium levels were consistent (4.4 - 7.2 µM) throughout the water column in February 2015 (Table 5, Figure 11) due to holomixis that occurred in late 2014. As the onset of meromixis occurred in summer epilimnetic ammonium levels slightly increased in June and July as *Artemia* abundance increased and excretion of fecal pellets raised the ammonium levels in the water column (Table 6). The July through October period had large increases in the level of ammonium in the hypolimnion below approximately 20 m (22.7 to 31.0 µM). Increases in the ammonium concentration in the hypolimnion during these months is associated with increases in algal debris and *Artemia* fecal pellets as these waste products sink to the bottom and decompose (Jellison 2011). Under anoxic conditions during summer thermal stratification ammonium concentrations tend to be higher at the sediment-water interface as bacterial nitrification ceases and the adsorptive capacity of the sediments is greatly reduced due to loss of the oxidized microzone (Wetzel, 2001). In November and December ammonium concentrations remained high between 8.3 and 16.6 µM compared to 2014 (3.3 and 3.9 µM). Ammonium was well-mixed throughout the water column by November and mixing remained complete through mid-December. In December differences in ammonium concentrations were slight between surface (8.3 µM at 2m) and low water column samples (10.5 µM at 28 m). This reduction in ammonium levels throughout the water column coincides with holomixis and increased uptake by phytoplankton as predation pressure from *Artemia* decreases in winter months. Average epilimnetic ammonium concentrations from integrated 9 meter samples never exceeded 9.7 µM (October) throughout the year with the exception of November (53.7 µM) due to unusually high ammonium concentrations (306.6 µM) reported at station 2. At all sampling stations average epilimnetic concentrations were at least 2 times higher than in 2014 with the exception of the month of November.

Phytoplankton

Seasonal changes were noted in the phytoplankton community, as measured by chlorophyll *a* concentration (Tables 7 and 8, Figure 12). On the February survey, epilimnetic chlorophyll a levels averaged 72.4 µg/L (Table 8). Within the epilimnion, lakewide mean chlorophyll values decreased through the spring and reached their lowest point in July (15.4 µg/L, Table 8). As the lake began to stratify in spring and zooplankton grazing increased, epilimnetic chlorophyll levels declined from 56.6 µg/L in April, to 18.4 µg/L in early June (Table 8). In July at station 6 chlorophyll concentrations varied from 17.9 µg/L at 2 meters to 102.5 µg/L at 24 meters in the hypolimnion (Table 7). Mean epilimnetic chlorophyll levels were 26% greater in June (42.7 µg/L) 47% greater in July (15.4 µg/L) and 21% greater in August (30.5 µg/L, Table 8) compared to 2014. By October as the water column began to mix the lakewide epilimnionic average had increased to 71.1 µg/l and reached its peak in November at 98.2 µg/L (Table 8). Overall both the lakewide trends (Table 8) and discrete sampling at Station 6 (Table 7) indicate changes in chlorophyll concentrations closely follow turnover conditions and fluctuations in grazing pressure from population changes of brine shrimp.

Brine Shrimp

Artemia Population Analysis and Biomass

Artemia population data is presented in Tables 9a through 9c as lakewide means, sector means associated standard errors and percentage of population by age class. As discussed in previous reports (Jellison and Rose 2011), zooplankton populations can exhibit a high degree of spatial and temporal variability. In addition, when sampling, local convergences of water masses may concentrate shrimp above overall means. For these reasons, Jellison and Rose have cautioned that the use of a single level of significant figures in presenting data is inappropriate, and that the reader should always consider the standard error associated with *Artemia* counts when making inferences from the data.

Artemia Population

Hatching of overwintering cysts had already initiated by February as the mid-February sampling detected an instar lakewide mean abundance of 10,098 +/- 2,014/m^2. The overwhelming majority (97.5%) of the instars in mid-February were instar age classes 1 and 2. Instar abundance increased through mid-April to a peak of 66,841 +/- 20,249/m^2 which was less than half the density of April 2014 peak instar counts. Similar to 2014 in early spring adults continued to be essentially absent. The 2015 peak *Artemia* lakewide abundance of 80,624 +/- 23,893/m^2 was recorded on the April 16th survey. Adults matured later in 2015 compared to 2014. By early June, adult *Artemia* comprised 26% of the *Artemia* population compared to 34% in mid - May of 2014. The instar analysis indicated a diverse age structure of instars 1-7 and juveniles (instars 8-11) in April. In early June, females with cysts were first recorded. June females with cyst abundance peaked at 5,996 +/- 691/m^2 followed closely by July (5,646 +/- 518/m^2). By August reproduction decreased significantly, with instars and juveniles comprising only 18% of the population. The greatest summer adult *Artemia* abundance occurred in June (18,699 +/- 2,116/m^2) which was less than half of the 2014 July peak (42,298 +/- 4,128/m^2). By August the adult population declined by 66% (5,839 +/- 727/m^2) compared to 75% from July (42,298 +/- 4,128/m^2) to August (10,776 +/- 1,839/m^2) in 2014. In mid-October, adult shrimp numbered 239 +/- 26/m^2, dropping to a low of 44 +/- 18/m^2 in November and 38 +/- 18/m^2 in December.

Instar Analysis

The instar analysis, conducted at seven stations, showed patterns similar to those shown by the lakewide and sector analysis, but provide more insight into *Artemia* reproductive cycles occurring at the lake (Table 10). Instars 1 and 2 were most abundant in February and March as overwintering cysts were hatching. In April various age classes of instars 1-7 and juveniles were present and comprised approximately 99.5% of the *Artemia* population while adults comprised the remainder (0.5%). By mid-June juvenile and instar abundance represented about 59.5% of the age structure population. The presence of late stage instars and juveniles indicate survival and recruitment into the population. Instar and juvenile abundance decreased to 20.5% in July and reached a low in August of 18% of the *Artemia* population. Adult abundance decreased from 72.5% in September to 8.8% in December while instar and juvenile age classes increased from 27.5% to near 91.2% over the same period. The greatest reduction in lakewide *Artemia* abundance occurred from September to October (79%, Table 9a) compared to a 79% (Table 9a) reduction from July to August in 2014. While proportions of *Artemia* age classes changed over the year, adult, juvenile and instar abundances declined considerably in October, November and December as anticipated (Table 9a).

Biomass

Mean *Artemia* biomass values were low in February and March, ranging from 0.81 gm/m^2 in February to 1.71 gm/m^2 in March (Table 11). Mean lakewide *Artemia* biomass peaked at 32.3 gm/m^2 in early-June, and declined in mid – June to 14.1 gm/m^2 before declining to 6.78 gm/m^2 in August. By October, mean lakewide biomass had declined to 0.43 gm/m^2, and was minimal in November and December (Table 11). Biomass values were greater in the east with the exception of April, early June and July. In early June during peak juvenile shrimp abundance biomass values were higher in the west at 39.6 gm/m^2 compared to 24.9 gm/m^2 in the east.

Reproductive Parameters and Fecundity Analysis

By early June, fecund females were plentiful enough to conduct fecundity analysis (Table 9c, Table 12, Figure 13). In mid-June approximately 99.3% of females were ovigerous, with 83.2% oviparous (cyst-bearing), 12.5% ovoviviparous (naupliar eggs) and 3.5% undifferentiated eggs (Table 9c). From June through September, over 95% of females were ovigerous with the majority (81-85%) oviparous. October had the most even distribution among female reproductive egg classes with 15% ovoviviparous, 50% oviparous, 25% undifferentiated and 10% empty egg sacs (Table 9c).

The lakewide mean fecundity showed pronounced seasonal variation. The lakewide mean fecundity was initially 42.5 +/- 1.0 egg per brood in early-June, decreasing slightly to 36.9 +/- 1.3 eggs per brood in mid-June and 28.2 +/- 1.5 in July (Table 12). Lakewide fecundity increased to 39.1 +/- 1.8 eggs per brood in August and reached a high of 56.8 +/- 2.8 eggs per brood in September. Although fecund females were documented during population analysis in October, densities were too low to conduct fecundity analysis of females. The majority of fecund females (84-100%) were oviparous, while ovoviviparous females with naupliar eggs constituted the remainder. Little difference was observed in fecundity between the western and eastern sectors. Typically mean female lengths are positively correlated with mean eggs per brood. In 2015 the opposite pattern was observed with the second lowest mean length (9.9 mm) corresponding with the highest mean brood size for the year (56.8 eggs per brood). The largest mean females (12.2 mm) were recorded in mid-June when mean brood size was the second lowest for the year (Table 12). In 2015 mean female length for all months were greater than the largest mean female length in 2014 (9.7 mm). The number of indented cysts remained relatively constant between 41% and 56% (Table 12).

Artemia Population Statistics

The calculated seasonal peak in adult *Artemia* of 22,627/m^2 was the second lowest peak recorded and about half the value of the long term mean peak (Table 13). The mean and median were also below average (8,527 vs. 19,327/m^2 and 6,035 vs 17,947/m^2). The centroid is the calculated center of abundance of adults. The centroid day of 186 in 2015 corresponds to July 5th and was 6 days earlier than in 2014. The mean, median, peak and centroid data for 2014 was misreported in the 2014 annual report and has been corrected and reported in this document (Table 13). The corrected mean, median and peak are higher by 7%, 4% and 12% respectively. The 2015 centroid day is 10 days earlier than 2013.The long-term mean centroid day for the time period 1979-2015 is 209 (July 28). Figure 14 shows daily lakewide mean adult *Artemia* values for 1982-2015. 2013 was the first year since the most recent episode of meromixis in 2011 that ammonium previously contained in the hypolimnion was fully available for phytoplankton. The year 2012 marked the 4th time that Mono Lake shifted from meromixis to monomixis during the period of record. There is data to suggest that years following the onset of monomixis have coincided with high adult *Artemia* abundance at Mono Lake (Figure 15). The long term data show 1989 and 2004 as the 2nd and 3rd highest adult density recorded from 1979-2013 (Table 12, Figure 14). The longest periods of meromixis, 1983-1987 and 1995-2002 ended just previous to these years (see Figure 6). Years such as 2014 that follow higher abundance years see a subsequent decline the following year of almost 50% (Table 13). Please see the appendix for a further explanation of change of ecological conditions following historic meromictic periods. In 2015 mean *Artemia* abundance continued to decline.

DISCUSSION

Thermal and Chemical Stratification

In 2015, Mono Lake experienced a net reduction in elevation of 1.1 feet and holomixis or complete autumnal mixing for the fourth year in a row. Following winter holomixis, thermal stratification was present by early June and the lake was strongly stratified by mid-June. Thermal stratification was observed as late as October. By November an isothermal water column was present indicating full mixing of the water column.

Conductivity data indicated a salinity gradient with the greatest difference in specific conductivity in the epilimnion and hypolimnion occurring in July and August. The increase in conductivity observed in September and October in the epilimnion is due to more saline hypolimnetic water mixing with surface waters. In addition, the 0.4 ft drop in lake elevation observed in late summer may have influenced conductivity by decreasing lake volume. The seasonal reduction of lake volume and subsequent increases in salinity could be intensified with reduced freshwater inflows during drought years.
These changes were evident in November and December as conductivity was greatest and consistent throughout the water column during these months.

Dissolved Oxygen
Dissolved oxygen values followed the seasonal pattern generally observed at Mono Lake. DO levels in February below 5 m were low (<1mg/L) compared to oxygen levels reported in November and December of 2014. Perhaps biological oxygen demand from microbial decomposition in the hypolimnion persisted throughout the water column for months after fall turnover (2014). DO levels slowly increased during the spring, average DO levels within the first 15 m of the water column were 5.6 mg/L in March and 3.4 mg/L in April. During the summer months (mid-June through August) average epilimnetic DO levels were 3 to 4 times higher than in 2014 (<1.1 mg/L). 2015 DO levels are more in line with historic summer epilimnetic DO concentrations (compared to 2014) which have not been much below 2 mg/L (Jellison, 1993). DO levels were lowest in early June with a maximum of 2.4 mg/L reported within the first 4 m of the lake surface.

As algal populations recovered in the late summer and fall due to decreasing shrimp numbers, average dissolved oxygen values in the epilimnion (15 m) increased quickly in mid-June (4.2 mg/L), July (4.8 mg/L), August (3.2 mg/L) and September (3.8 mg/L) before reducing slightly again in October (2.2 mg/L). With the lake fully mixed by November, average dissolved oxygen levels within the first 15 meters of the lake were between 1.1 and 2.3 mg/L in November and between 1.1 and 2.7 mg/L in December.

Ammonium and Chlorophyll

Nitrogen is the primary limiting macronutrient in Mono Lake as phosphate is abundant throughout the year (Jellison et al 1994 in Jellison 2011). External inputs are low, and vertical mixing controls much of the annual internal recycling of nitrogen.

Ammonium sampling further supports the presence of a monomictic lake regime in 2015. Prior to summer stratification ammonium concentrations were similar throughout the water column. The June through October period showed large increases in the level of ammonium in the hypolimnion as algal debris and *Artemia* fecal pellets accumulated and decomposed in the hypolimnion. In addition, in the anoxic hypolimnion internal loading occurs as ammonium released from the sediments further increases ammonium levels. Ammonium concentrations ranged between 10.5 and 16.6 µM throughout the water column by mid-November and between 8.3 to 10.5 µM through mid-December. Generally low levels of ammonium in spring/winter months coincided with the greatest concentration of mean chlorophyll in the epilimnion across all stations sampled and throughout the water column at station 6. Mean epilimnetic ammonium concentration were consistent from February through mid-June (5.2 to 6.0 µM) likely due to lower abundance of juvenile and adult *Artemia* compared to historical levels.

Chlorophyll *a* is the most abundant form of chlorophyll found bound within the cells of the algae comprising the phytoplankton community at Mono Lake. Chlorophyll *a* is therefore monitored as an indicator of phytoplankton activity and abundance.

Epilimnetic chlorophyll levels were initially moderate from February through April and decreased 49% by early-June and another 35% by mid-June coincident with the increase in juvenile and adult shrimp numbers. Mean epilimnetic chlorophyll levels were lowest in July (15.4 µg/L) following peak adult *Artemia* abundance in June. Shrimp numbers declined in August and September with mean chlorophyll levels nearly recovered to spring levels by September. During this time shrimp numbers were low, algal biomass increased and dissolved oxygen levels began to recover. Mean epilimnetic chlorophyll levels continued to increase throughout the year until reaching their peak in December (97.1 µg/L) which was almost twice that of April (56.6 µg/L).

Brine Shrimp

Mean adult *Artemia* abundance was 37% lower in 2015 compared to 2014, and peak adult abundance was about 47% lower. Total brine shrimp numbers (adults and instars) peaked in April and were almost completely represented by early stage instars (Table 9a). Recruitment of early instars to the population was evident by increasing late stage instars in mid-April and early June and peak adult numbers in mid-June followed closely by July. Adult abundance peaked in mid-June and was representative of the long term trend. The centroid peak in abundance occurred on July 5th which was 22 days earlier than the long term mean. Mean biomass was greatest in early summer reaching its peak in early June and was about 50% lower in both mid-June and July. This peak biomass coincides with the greatest abundance (sum) of juvenile and adults occurring in early June. By mid-June juvenile abundance decreased 54% while adult abundance increasing only 21% indicating low recruitment over this 2 week period. Overall juvenile and adult abundance (sum) reduced 18% over the same period. Overall shrimp numbers reduced more than 40% from April to early June and over 50% from mid-June to mid-July which is earlier than the long term trend. By October adult densities were low (660 m^2). A high rate of ovigery and high brood numbers were observed in September. Brood numbers are typically highest in October and were not reported this year due to low density of fecund females. Although plankton numbers were sufficient to support populations, low oxygen levels the previous year may have impacted *Artemia* hatching in the spring. Long-term parameters indicate a below average seasonal peak in adult *Artemia* with mean abundance 50% lower than the long term mean.

Changes in Algal Biomass, Adult Density Distribution and Lake Transparency

Lake transparency as measured by Secchi depth was very low throughout the year (<1 m) with a mean of 0.91 m in July compared to a 2014 July mean of 1.5 m indicating a continued trend of lower lake transparency. 2014 mean July transparency (1.5 m) was over three times lower than July 2013 (5.08m). June and August Secchi depths were slightly lower than 2014 measurements. Average lake wide Secchi depth was 0.55 m in 2015 compared to 0.66 m in 2014. The greatest Secchi depth for 2015 coincides with the lowest mean epilimnetic density for chlorophyll-a (15.4 µg/L), but was almost 2 times greater than July 2014 densities (8.1 µg/L). August mean epilimnetic chorophyll-a densities were slightly higher (30.5 µg/L) than 2014 August densities (24.2 µg/L). Secchi depths indicate that Mono Lake was eutrophic and lake transparency did not increase by several meters in summer months as occurred prior to 2014. Despite seasonal and inter-year variation, this may be a continuation of a long term trend of increasing epilimnetic chlorophyll *a* concentrations at Mono Lake (Jellison, 2011). Average water temperatures were warmer throughout the water column from February to early June compared to 2014. Compared to 2014 the greatest difference in average temperatures was observed in July (4.8˚C lower). Average Fall and early Winter temperatures were lower (0.8 – 2.6°C) compared to 2014 after increasing about 2°C the previous year.

Continued reduced lake levels coupled with warm water temperatures and readily available nutrients may continue to support high concentrations of algal biomass. Excess algal biomass can result in self shading and reduce light attenuation throughout the water column inhibiting photosynthesis by plankton in a reduced euphotic zone. Increased senescence of light limited plankton may result in reduced oxygen availability throughout the water column. Although dissolved oxygen levels increased in 2015, biological oxygen demand from vertical mixing may explain continued low summer epilimnetic DO levels (< 2 mg/L) compared to historical data (Jellison, 1993). Direct measurement of photosynthetically active radiation (PAR) may be beneficial to determine changes in depth of the euphotic zone available for use by phytoplankton. Density of chlorophyll a seems to remain relatively constant in 2015 while Secchi depth transparency continues to slightly decline. Potential abiotic factors such as increased sedimentation through wind erosion may be contributing to increased turbidity as the lake level continues to decline and regional scale drying patterns potentially contribute to reduced lake clarity. As light availability reduces throughout the water column algal assemblages may be shifting towards phylogenies that thrive in more light limited conditions. Changes in algal assemblage type and distribution may result in less palatable food items for Mono Lake *Artemia* (Winkler, 1977, Reeve, 1963). Chlorophyll a densities are not useful in measuring changes in plankton communities therefore any potential changes in specific plankton assemblages are not captured utilizing the current sampling protocol established by Jellison.

Sizeable declines in year to year mean adult *Artemia* densities are quite common throughout Mono Lake’s monitored history (Table 13). Historic shifts from meromictic to monmictic cycles also exhibit a marked increase in adult shrimp densities followed by a substantial decrease the following year as occurred in 2014. Less common, are shorter intervals of high adult density during summer months as occurred the past two years (Figure 14). Mean adult densities were very low during April (396 m^2) and were only 5,839 m^2 by August (Table 9a). A similar pattern was observed in 2010, with low adult densities in May (1,462 m^2) and moderate numbers by August (11,714 m^2). 2015 continues a trend of larger 1st generations with low summer recruitment and rapid late summer/autumn declines. This general trend has been observed since 2004 and is disadvantageous to migrating grebes that depend on brine shrimp (Jellison, 2011). Despite shifts in timing of population changes overall abundance remains consistent even since 2004. However mean adult *Artemia* abundance was the lowest on record despite the presence of historically lower lake levels. Despite these changing conditions brine shrimp reproductive strategies enable them to persist throughout both changing lake mixing regimes and periods of sometimes rapidly changing lake levels. Migratory birds that visit Mono Lake in the summer and early fall are likely to be favored under these conditions.

Summary of Changes in Brine Shrimp Populations in Response to Breakdown of Meromixis

Recent Period of Monomixis and Importance to Biota

The health of *Artemia* populations are linked to primary food sources such as phytoplankton. The main nutrients required by phytoplankton are nitrogen and phosphorous. In Mono Lake nitrogen and its external inputs are limited but phosphorous is abundant. The majority of nitrogen biologically available for direct uptake by phytoplankton is in the form of ammonium. In Mono Lake ammonium is the limiting nutrient for primary productivity and relative contributions from internal nutrient cycling and brine shrimp have been documented (Jellison and Melack 1986, 1988). Ammonium bound in the sediments is made available by internal nutrient recycling driven by changes in thermal and chemical density stratification of Mono Lake. Historically, Mono Lake has shifted between meromictic and monomictic conditions dependent on a multitude of factors including climatic conditions such as temperature, evaporation, wind, freshwater inputs from precipitation and runoff, and exports from diversions. All of these influences affect stratification and mixing dynamics of Mono Lake. Mono Lake exhibited a monomictic mixing regime from 2008-2010, was meromictic in 2011, returned to monomixis in 2012 and remained so in 2013-15. Monomixis, or annual mixing once a year, is important to the nutrient cycle at Mono Lake as it returns nutrients, most importantly, ammonium back to the epilimnion for use by phytoplankton.

Historic Shifting from Meromictic to Monomictic Conditions

Analysis of long term mixing regimes at Mono Lake is important as water column mixing and internal nutrient cycling affect biota including *Artemia* population dynamics. As stated previously the most recent episode of monomixis (2012-2013) marks the 4th time since 1982 that Mono Lake has shifted from a meromictic to a monomictic state. Although vertical mixing does not provide the sole source of ammonium in Mono Lake, it is especially important for primary producers in the spring and fall as contributions from *Artemia* excretions are greatly reduced (Melack, 1988, Jellison and Melack, 1993). *Artemia* populations have fluctuated year to year since LADWP began monitoring Mono Lake in 1982 (see Table 13, Figure 14). Historically *Artemia* abundance has been high in years following the onset of monomixis including 1989, 2004, 2009 and 2013 (Figure 15). Ammonium liberated from anoxic sediments is made biologically available to plankton the fall and winter (1st year of monomixis) previous to years when annual *Artemia* abundance peaks have occurred. Perhaps an abundance of primary production in the year following breakdown of meromixis allow brine shrimp populations to peak the subsequent spring and summer as evidenced by high abundance in those years. Jellison and Rose report high values for primary production in those years following the breakdown of meromixis (2011), although there are occurrences when primary production was high during years of meromixis (Jellison and Rose, 2011). Studies have shown that spring generation brine shrimp raised at high food densities develop more quickly, begin reproducing earlier and that abundance of algae may likely affect year to year changes in shrimp abundance (Jellison and Melack, 1993).

While availability of food sources and nutrients are important they do not fully determine year to year abundance of *Artemia* (subsequent to meromixis). The unique life history of female brine shrimp allow for dormant cysts to stay viable for years. It is known that diapausing cysts require oxygen for hatching (Lenz, 1984). Under meromictic conditions when much of sediment has been anoxic for multiple years a large percentage of cysts likely fail to hatch. When sediments finally become reoxygenated during monomixis dormant cysts may begin to hatch (Jellison et al. 1989). The combination of reoxygenated dormant cyst hatching and mixing of ammonium rich water may likely explain peak years in adult brine shrimp abundance following long periods of meromixis.

Mono Lake Volume and Changes from Fluctuation in Freshwater Inputs

When evaluating the mean surface elevation from 1979 to 2014 a pattern may be emerging between declining lake elevation post meromixis and annual brine shrimp abundance. The greatest mean adult shrimp density documented since 1979 occurred in 1982 when mean annual surface elevation was at the lowest recorded level in the past 35 years (Figure 15, Figure 16). During the preceding years water exports were high resulting in minimal release to Mono Lake (Figure 17). This year (1982) was subsequent to a period of several years of monomixis and was followed by a large release of freshwater in 1983 which set up conditions for a 5 year period of meromixis. The 2nd and 3rd highest mean adult *Artemia* densities occurred in 1989 and 2004 which are years subsequent to the breakdown of meromixis. These were years following below normal runoff years resulting in declining lake levels due to decreased freshwater input. The reduced lake volume combined with reduced fresh water input lessens the thermal and chemical gradient between the upper and lower water column and Mono Lake begins to mix. There may be a long term pattern of population booms during transition periods following the breakdown of meromixis (Figure 15, Figure 16). Despite the benefits from the release and circulation of ammonium rich water during initial years post meromixis, adult brine shrimp populations greatly reduce the following years during both monomictic and meromictic periods. In 2014 there was a 48% decrease of mean adult *Artemia* which is similar to historical second year post meromixis conditions. Mean adult *Artemia* decreased 45% in 1990, 44% in 2005 and 43% in 2010 following year one post-meromictic conditions (Figure 15). Despite year to year fluctuations long term trends for adult *Artemia* abundance continues to be stable.

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Table 1. Secchi Depths (m); February – December 2015.

STATION	SAMPLING DATE										
	18-Feb	10-Mar	16-Apr	2-Jun	19-Jun	23-Jul	18-Aug	21-Sep	21-Oct	12-Nov	16-Dec
Western Sector											
1	0.50	0.45	0.50	0.55	0.80	0.90	0.40	0.50	0.60	0.30	0.60
2	0.50	0.40	0.55	0.55	0.80	0.95	0.50	0.50	0.60	0.50	0.60
3	0.45	0.45	0.45	0.60	0.80	0.90	0.50	0.50	0.50	0.50	0.60
4	0.40	0.40	0.40	0.55	0.70	0.85	0.50	0.50	0.50	0.50	0.60
5	0.40	0.40	0.45	0.60	0.70	0.90	0.50	0.50	0.50	0.50	0.55
6	0.40	0.40	0.45	0.55	0.70	0.90	0.50	0.50	0.40	0.45	0.60
AVG	0.44	0.42	0.47	0.57	0.75	0.90	0.48	0.50	0.52	0.46	0.59
SE	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.00	0.03	0.03	0.01
n	6	6	6	6	6	6	6	6	6	6	6
Eastern Sector											
7	0.40	0.40	0.45	0.50	0.70	0.93	0.50	0.55	0.50	0.50	0.60
8	0.40	0.50	0.45	0.60	0.80	0.95	0.50	0.50	0.50	0.40	0.50
9	0.60	0.40	0.45	0.50	0.70	0.90	0.70	0.50	0.40	0.50	0.60
10	0.50	0.40	0.45	0.45	0.80	0.90	0.50	0.55	0.40	0.45	0.50
11	0.35	0.35	0.40	0.45	0.75	0.95	0.60	0.50	0.50	0.40	0.60
12	0.40	0.40	0.40	0.55	0.70	0.90	0.60	0.55	0.40	0.50	0.60
AVG	0.44	0.41	0.43	0.51	0.74	0.92	0.57	0.53	0.45	0.46	0.57
SE	0.04	0.02	0.01	0.02	0.02	0.01	0.03	0.01	0.02	0.02	0.02
n	6	6	6	6	6	6	6	6	6	6	6
Total Lakewide											
AVG	0.44	0.41	0.45	0.54	0.75	0.91	0.53	0.51	0.48	0.46	0.58
SE	0.03	0.02	0.02	0.02	0.02	0.01	0.03	0.01	0.03	0.03	0.02
n	12	12	12	12	12	12	12	12	12	12	12

Table 2. Temperature (°C) at Station 6, February – December 2015.

Depth (m)	18-Feb	10-Mar	16-Apr	2-Jun	23-Jun	15-Jul	18-Aug	21-Sep	21-Oct	12-Nov	16-Dec
0	9.9	9.6	10.5	19.8	23.3	22.2	22.1	17.1	15.0	11.1	5.7
1	7.6	6.3	7.2	17.5	22.3	20.9	20.5	16.3	14.3	10.1	5.5
2	6.5	6.1	7.1	15.4	21.0	20.2	19.7	16.2	14.3	9.9	5.5
3	6.2	6.8	7.1	15.1	19.7	20.0	19.5	16.2	14.3	9.8	5.5
4	5.7	6.8	7.1	14.7	19.2	19.9	19.4	16.2	14.4	9.8	5.5
5	5.2	6.3	7.1	14.3	18.6	20.0	19.5	16.2	14.4	9.8	5.5
6	4.9	5.6	7.0	13.3	17.8	19.6	18.7	16.2	14.5	9.9	5.5
7	4.8	5.4	6.9	12.3	15.5	19.2	18.5	16.4	14.5	9.9	5.5
8	4.8	5.4	6.8	11.2	14.0	16.3	18.3	16.3	14.4	9.9	5.5
9	4.8	5.4	6.7	11.0	10.5	12.7	17.9	16.0	14.4	9.9	5.5
10	4.8	5.4	7.0	10.6	9.6	11.0	17.4	15.9	14.4	9.9	5.5
11	4.8	5.3	7.0	9.7	9.0	10.1	13.2	15.8	14.3	9.9	5.5
12	4.7	5.2	7.0	8.9	8.2	8.8	10.5	15.7	13.8	9.9	5.5
13	4.7	5	7.0	8.2	7.9	8.3	9.3	14.4	13.1	9.9	5.5
14	4.7	4.9	7.0	7.9	7.8	8.0	8.7	13.5	11.5	9.9	5.5
15	4.7	4.8	7.0	7.6	7.6	7.9	8.3	11.4	10.5	10.0	5.5
16	4.6	4.7	6.9	7.5	7.5	7.6	8.0	10.7	9.5	10.0	5.5
17	4.6	4.7	6.8	7.3	7.4	7.6	7.9	9.9	9.3	10.0	5.5
18	4.6	4.7	6.7	7.1	7.3	7.4	7.8	9.3	9.3	10.0	5.5
19	4.6	4.7	6.6	7.0	7.1	7.3	7.7	9.1	9.4	10.0	5.5
20	4.5	4.7	6.5	6.8	7.0	7.2	7.6	8.9	9.3	10.0	5.5
21	4.5	4.6	6.4	6.8	6.9	7.1	7.4	8.6	8.9	9.9	5.5
22	4.5	4.6	6.2	6.7	6.9	7.1	7.3	8.5	8.9	9.9	5.5
23	4.5	4.6	6.2	6.7	6.8	7.0	7.2	8.2	8.8	9.9	5.4
24	4.5	4.6	6.2	6.6	6.8	6.9	7.2	8.0	8.8	9.9	5.4
25	4.4	4.6	6.1	6.6	6.7	6.9	7.1	7.6	8.8	10.0	5.4
26	4.4	4.6	6.0	6.5	6.7	6.8	7.0	7.6	8.8	10.0	5.4
27	4.4	4.5	5.8	6.4	6.6	6.8	7.0	7.6	8.7	10.0	5.4
28	4.4	4.5	5.7	6.4	6.6	6.8	6.9	7.6	8.4	10.0	5.4
29	4.4	4.5	5.6	6.3	6.4	6.7	6.9	7.6	8.4	9.9	5.4
30	4.4	4.5	5.3	6.3	6.4	6.7	6.8	7.6	8.3	9.7	5.4
31	4.4	4.6	5.2	6.2	6.4	6.6	6.8	7.6	8.4	9.7	5.4
32	4.4	4.5	5.1	6.1	6.3	6.5	6.8	7.4	8.7	9.6	5.4
33	4.4	4.5	5.1	6.1	6.3	6.4	6.7	7.4	8.7	9.6	5.4
34	4.4	4.6	5.1	6.1	6.3	6.4	6.7	7.4	8.7	9.5	5.4
35	4.4	4.6	5.0	6.1	6.2	6.4	6.7	7.4	8.7	9.4	5.4
36	4.4	4.6	5.0	6.1	6.2	6.3	6.6	7.3	8.4	9.3	5.4
37	4.4	4.6	5.0	6.0	-	6.3	6.6	7.3	8.4	9.2	5.4
38	4.4	4.6	5.0	6.0	-	6.3	6.6	7.2	8.0	9.2	5.4
39	4.5	4.6	4.9	6.0	-	6.3	6.5	7.0	7.7	9.3	5.4
40	4.5	4.6	4.9	6.0	-	6.2	6.5	7.0	7.8	9.3	5.4

Table 3. Conductivity (mS/cm $^{-1}$at 25°C) at Station 6, June – December 2015.

Depth (m)	23-Jun	15-Jul	18-Aug	21-Sep	21-Oct	12-Nov	16-Dec
1	84.8	85.2	86.0	86.8	87.2	88.7	91.4
2	84.9	85.2	86.0	86.8	87.3	88.8	91.4
3	85.2	85.3	86.1	86.9	87.3	88.8	91.4
4	85.0	85.4	86.0	86.9	87.2	88.8	91.4
5	85.6	85.1	86.1	87.1	87.2	88.8	91.4
6	87.0	85.4	86.0	87.0	87.2	88.8	91.4
7	87.6	86.1	85.9	86.9	87.2	88.8	91.4
8	87.9	86.7	86.1	87.0	87.2	88.8	91.4
9	88.2	87.4	86.1	87.0	87.3	88.8	91.4
10	88.7	88.0	87.4	87.0	87.2	88.8	91.4
11	88.7	88.3	87.8	86.5	87.2	88.8	91.4
12	88.8	88.4	88.0	87.1	86.9	88.8	91.4
13	88.8	88.6	88.3	87.0	87.5	88.8	91.4
14	88.9	88.7	88.4	87.6	88.1	88.8	91.4
15	89.0	88.8	88.6	87.8	88.1	88.8	91.4
16	89.1	88.9	88.7	88.3	88.4	88.8	91.4
17	89.1	89.0	88.8	88.4	88.5	88.8	91.4
18	89.1	89.0	88.7	88.3	88.5	88.8	91.4
19	89.2	89.1	88.9	88.5	88.6	88.8	91.4
20	89.3	89.2	88.9	88.6	88.6	88.8	91.4
21	89.3	89.2	89.0	88.6	88.5	88.8	91.4
22	89.4	89.2	89.0	88.6	88.6	88.8	91.4
23	89.4	89.3	89.1	88.8	88.6	88.8	91.4
24	89.4	89.3	89.2	88.8	88.7	88.8	91.4
25	89.4	89.4	89.2	89.0	88.6	88.8	91.4
26	89.5	89.4	89.2	89.0	88.7	88.8	91.4
27	89.5	89.4	89.2	89.0	88.8	88.9	91.4
28	89.5	89.4	89.3	89.0	88.8	88.8	91.4
29	89.6	89.5	89.3	88.9	88.8	88.8	91.4
30	89.7	89.5	89.3	88.9	88.9	88.9	91.4
31	89.7	89.6	89.3	89.1	88.7	88.9	91.4
32	89.7	89.6	89.4	89.1	88.8	88.9	91.4
33	89.7	89.6	89.4	89.1	88.7	89.0	91.4
34	89.8	89.6	89.4	89.1	88.8	89.0	91.4
35	89.8	89.6	89.5	89.1	88.6	89.1	91.4
36	-	89.7	89.5	89.1	88.9	89.1	91.5
37	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-

Table 4. Dissolved Oxygen* (mg/l) at Station 6, February – December 2015.

Depth (m)	18-Feb	10-Mar	16-Apr	2-Jun	19-Jun	23-Jul	18-Aug	21-Sep	21-Oct	12-Nov	16-Dec
1	10.4	7.6	4.0	2.3	5.4	6.0	4.5	4.8	2.9	-	2.7
2	10.7	7.3	4.1	2.4	5.3	6.0	4.4	5.0	2.8	2.3	2.6
3	10.2	6.8	3.9	2.4	5.3	6.0	4.4	5.0	2.7	2.2	2.4
4	7.3	6.9	3.7	2.4	5.2	6.0	4.3	5.0	2.6	2.1	2.3
5	2.0	6.9	3.6	2.3	5.0	5.9	4.3	4.9	2.5	2.0	2.2
6	0.9	6.2	3.5	2.2	5.0	5.6	3.8	4.5	2.5	2.0	2.2
7	0.8	5.7	3.3	1.8	4.6	5.6	3.3	4.6	2.4	1.9	2.0
8	0.7	5.2	3.1	1.6	4.5	4.8	3.2	4.4	2.3	1.9	1.9
9	0.7	5.2	3.0	1.5	4.3	4.7	3.0	4.1	2.3	1.7	1.8
10	0.6	5.2	3.1	1.3	4.1	4.4	2.8	3.5	2.2	1.6	1.6
11	0.9	5.1	3.2	1.1	3.7	4.2	2.4	3.1	2.1	1.5	1.6
12	0.8	4.9	3.3	1.0	3.3	4.2	2.1	2.9	2.0	1.4	1.4
13	0.9	4.0	3.3	0.9	2.8	3.7	2.1	2.5	1.6	1.2	1.3
14	0.9	3.8	3.3	0.9	2.3	3.0	2.1	2.0	1.4	1.2	1.2
15	0.9	3.5	3.3	0.9	2.0	2.5	2.0	1.4	1.3	1.1	1.1
16	0.9	3.2	3.2	0.9	1.6	2.0	2.0	1.1	1.2	0.9	1.0
17	1.0	3.3	3.1	0.8	1.3	1.8	2.0	1.0	1.0	0.8	0.9
18	0.9	3.2	3.1	0.8	1.3	1.5	1.9	0.9	1.0	0.8	0.7
19	1.1	3.1	2.9	0.7	1.2	1.2	1.8	0.8	1.0	0.7	0.7
20	1.0	3.0	2.8	0.7	1.1	1.1	1.8	0.8	0.9	0.6	0.6
21	1.0	2.9	2.7	0.7	1.0	1.0	1.7	0.7	0.9	0.6	0.5
22	0.9	2.6	2.5	0.7	1.0	0.9	1.6	0.7	0.8	0.6	0.5
23	0.9	2.5	2.3	0.6	1.0	0.7	1.6	0.6	0.7	0.5	0.5
24	0.8	2.5	2.3	0.7	0.9	0.6	1.3	0.6	0.7	0.4	0.5
25	0.7	2.3	2.2	0.6	0.8	0.6	1.3	0.5	0.7	0.4	0.5
26	0.7	2.3	2.2	0.6	0.8	0.5	1.2	0.5	0.7	0.4	0.5
27	0.6	2.2	2.0	0.6	0.7	0.4	1.1	0.4	0.6	0.4	0.5
28	0.5	2.2	1.8	0.6	0.6	0.4	1.1	0.4	0.6	0.4	0.5
29	0.3	2.0	1.7	0.6	0.6	0.4	1.0	0.4	0.6	0.3	0.5
30	0.2	2.0	1.5	0.6	0.5	0.4	1.0	0.4	0.6	0.4	0.5
31	0.3	1.8	1.3	0.6	0.5	0.4	0.9	0.4	0.6	0.4	0.5
32	0.4	1.7	1.0	0.5	0.4	0.4	0.9	0.4	0.6	0.4	0.5
33	0.2	1.9	0.8	0.5	0.4	0.4	0.8	0.4	0.6	0.4	0.5
34	0.2	1.7	0.7	0.5	0.4	0.4	0.7	0.3	0.6	0.4	0.5
35	0.2	1.6	0.7	0.5	0.4	0.4	0.6	0.3	0.6	0.5	0.5
36	0.2	1.3	0.5	0.5	0.4	0.4	0.5	0.3	0.6	0.5	0.5
37	0.2	1.2	0.4	0.5	-	0.4	0.5	0.3	0.6	0.5	0.5
38	0.2	1.1	0.3	0.5	-	0.3	0.5	0.3	0.3	0.5	0.5
39	0.3	1.1	0.3	0.4	-	0.4	0.4	0.2	0.3	0.5	0.5
40	0.4	0.7	0.3	0.4	-	0.3	0.4	0.2	0.3	0.5	0.5

*YSI probe error (+/- 0.2 mg/L).

Table 5. Ammonium (µM) at Station 6, February through December 2015.

Depth (m)	18-Feb	10-Mar	16-Apr	2-Jun	23-Jun	15-Jul	18-Aug	21-Sep	21-Oct	12-Nov	16-Dec
1	-	-	-	-	-	-	-	-	-	-	-
2	5.5	6.1	5.0	6.1	5.5	6.7	7.2	9.4	9.4	16.6	8.3
3	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-
8	5.5	6.1	5.5	6.7	5.5	7.2	7.2	9.4	10.0	10.5	8.3
9	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-
12	5.5	6.1	5.5	6.1	12.2	17.7	17.2	8.3	13.3	10.5	8.9
13	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-
16	4.4	6.1	6.1	9.4	12.2	22.7	23.8	18.3	21.1	10.5	10.5
17	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-
20	5.5	6.1	6.1	10.5	14.4	22.7	24.9	24.9	24.9	11.1	10.0
21	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-
24	6.1	8.3	6.1	11.6	18.8	23.3	27.7	29.4	24.4	11.1	10.0
25	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-
28	7.2	10.0	6.1	17.2	18.8	23.8	26.6	31.0	20.0	11.6	10.5

Laboratory detection limit of 2.8µm.

Table 6. 9-meter integrated values for Ammonium (µm) – February to December 2015.

Station	18-Feb	10-Mar	16-Apr	2-Jun	23-Jun	15-Jul	18-Aug	21-Sep	21-Oct	12-Nov	16-Dec
1	5.0	5.5	5.5	5.0	5.5	6.7	6.7	8.3	9.4	11.6	8.9
2	5.0	5.5	5.5	5.5	5.5	7.2	6.7	8.9	10.5	306.6	9.4
5	6.1	6.7	5.0	5.5	5.5	13.9	7.2	8.3	10.0	15.0	9.4
6	5.5	6.7	5.0	5.5	5.5	6.7	7.2	9.4	8.9	9.4	7.8
7	5.5	5.5	5.5	5.5	5.5	7.8	6.7	8.9	9.4	9.4	10.0
8	5.5	6.1	5.0	5.5	5.5	7.2	7.2	8.9	10.0	11.1	8.3
11	5.5	6.1	5.0	5.5	5.5	7.2	6.7	8.3	10.0	12.8	8.3
Mean	5.5	6.0	5.2	5.5	5.5	8.1	6.9	8.7	9.7	53.7	8.9
SE	0.13	0.19	0.11	0.00	0.00	1.04	0.11	0.16	0.22	45.53	0.32

Laboratory detection limit of 2.8µm.

Table 7. Chlorophyll *a* (µg /l) at Station 6 – February through December 2015.

Depth (m)	18-Feb	10-Mar	16-Apr	2-Jun	23-Jun	15-Jul	18-Aug	21-Sep	21-Oct	12-Nov	16-Dec
1	-	-	-	-	-	-	-	-	-	-	-
2	77.0	69.5	53.3	28.2	22.6	17.9	31.2	57.9	60.2	62.3	100.6
3	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-
8	84.3	57.9	60.1	41.4	45.5	47.7	38.4	64.3	87.4	107.7	94.9
9	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-
12	66.0	80.3	59.3	46.7	68.7	84.4	100.0	75.2	85.5	88.5	93.9
13	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-
16	70.8	81.8	64.9	51.2	60.9	97.1	101.2	100.0	97.6	75.2	92.2
17	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-
20	77.4	77.3	64.9	63.2	65.9	91.5	79.2	73.9	98.5	84.3	100.4
21	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-
24	75.3	82.4	64.3	67.9	70.9	102.5	76.1	87.2	111.9	99.6	112.2
25	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-
28	71.7	73.5	47.5	72.9	68.2	83.5	86.4	115.0	98.1	104.7	99.8

Table 8. 9-meter integrated values for chlorophyll *a* (µg/l) – February to December 2015.

Station	18-Feb	10-Mar	16-Apr	2-Jun	23-Jun	15-Jul	18-Aug	21-Sep	21-Oct	12-Nov	16-Dec
1	72.4	60.2	51.7	25.9	15.2	14.1	33.8	64.7	72.2	118.7	102.5
2	70.6	66.1	46.5	31.7	18.7	13.3	31.3	56.4	62.1	79.2	106.2
5	73.7	66.7	49.6	30.7	21.1	11.8	33.1	75.6	59.1	113.6	107.8
6	75.9	57.9	56.9	24.9	9.3	14.4	31.7	58.2	74.0	109.6	105.2
7	67.6	81.5	62.6	28.6	25.4	15.3	27.9	72.0	80.8	83.3	88.9
8	73.7	86.8	64.4	29.8	20.8	25.2	28.7	71.8	75.6	98.8	87.7
11	73.2	75.0	64.7	29.5	18.4	13.7	26.9	56.8	74.0	84.0	81.2
Mean	72.4	70.6	56.6	28.7	18.4	15.4	30.5	65.1	71.1	98.2	97.1
SE	1.01	4.10	2.83	0.94	1.91	1.69	1.01	3.07	2.91	6.12	4.09

Table 9a. *Artemia* lake and sector means, 2015.

	Instars					Ad Female Ovigery Classification				
	1-7	8-11	Adult Total	Adult Males	Adult Female Total	empty	undif	cysts	naup	Total *Artemia*
Lakewide mean										
18-Feb	10,098	54	32	28	3	3	0	0	0	10,183
10-Mar	18,530	2	3	3	0	0	0	0	0	18,535
16-Apr	66,841	13,387	396	396	0	0	0	0	0	80,624
2-Jun	24,856	18,243	14,782	11,590	3,192	309	376	1,355	1,154	57,881
23-Jun	19,088	8,424	18,699	11,496	7,203	54	255	5,996	899	46,211
15-Jul	2,193	2,294	17,406	10,474	6,932	265	769	5,646	252	21,892
18-Aug	826	454	5,839	3,242	2,596	117	151	2,095	233	7,118
21-Sep	573	295	2,289	1,278	1,011	13	60	860	79	3,157
21-Oct	178	243	239	208	32	3	8	16	5	660
12-Nov	148	57	44	39	5	0	2	3	0	249
16-Dec	354	38	38	33	5	2	0	3	0	430
Western Sector mean										
18-Feb	5,615	3	6	6	0	0	0	0	0	5,624
10-Mar	7,633	38	44	38	6	6	0	0	0	7,715
16-Apr	104,896	17,062	429	429	0	0	0	0	0	122,388
2-Jun	19,611	18,350	15,104	11,670	3,434	510	537	1,368	1,019	53,065
23-Jun	22,052	9,443	21,033	13,467	7,565	54	429	5,848	1,234	52,529
15-Jul	2,395	3,227	17,645	10,965	6,680	202	681	5,470	328	23,266
18-Aug	920	366	3,913	2,363	1,550	69	151	1,267	63	5,199
21-Sep	444	224	1,909	1,030	879	13	60	715	91	2,577
21-Oct	221	277	205	180	25	3	6	13	3	703
12-Nov	54	9	0	0	0	0	0	0	0	63
16-Dec	54	19	13	9	3	3	0	0	0	85
Eastern Sector mean										
18-Feb	31,446	0	0	0	0	0	0	0	0	31,446
10-Mar	12,564	69	19	19	0	0	0	0	0	12,652
16-Apr	28,786	9,712	362	362	0	0	0	0	0	38,860
2-Jun	30,101	18,135	14,460	11,509	2,951	107	215	1,341	1,288	62,696
23-Jun	16,123	7,404	16,365	9,524	6,841	54	80	6,144	563	39,893
15-Jul	1,991	1,361	17,166	9,982	7,184	328	857	5,823	176	20,519
18-Aug	731	542	7,764	4,121	3,642	164	151	2,924	403	9,037
21-Sep	703	366	2,669	1,525	1,144	13	60	1,005	66	3,737
21-Oct	135	208	274	236	38	3	9	19	6	618
12-Nov	243	104	88	79	9	0	3	6	0	435
16-Dec	655	57	63	57	6	0	0	6	0	775

Table 9b. Standard errors of *Artemia* sector means (from Table 9a), 2015.

	Instars					Ad Female Ovigery Classification				
	1-7	8-11	Adult Total	Adult Males	Adult Female Total	empty	undif	cysts	naup	Total *Artemia*
SE of Lakewide mean										
18-Feb	2,014	18	13	13	3	3	0	0	0	2,023
10-Mar	4,465	2	2	2	0	0	0	0	0	4,464
16-Apr	20,249	4,245	198	198	0	0	0	0	0	23,893
2-Jun	2,271	2,881	2,169	1,700	588	126	105	236	325	5,859
23-Jun	2,188	963	2,116	1,395	847	30	87	691	245	3,142
15-Jul	330	543	1,267	916	607	62	106	518	73	1,849
18-Aug	130	66	727	323	419	26	25	355	64	770
21-Sep	76	46	312	180	141	4	14	120	20	409
21-Oct	45	51	26	27	4	2	3	4	3	100
12-Nov	48	26	18	18	2	0	2	2	0	89
16-Dec	129	17	18	17	2	2	0	2	0	154
SE of Western Sector mean										
18-Feb	1,210	3	4	4	0	0	0	0	0	1,205
10-Mar	1,826	24	23	24	6	6	0	0	0	1,847
16-Apr	33,280	6,065	271	271	0	0	0	0	0	39,269
2-Jun	2,074	3,100	2,865	2,268	813	222	165	352	226	7,324
23-Jun	2,570	870	2,422	1,805	801	54	136	608	366	3,312
15-Jul	490	965	2,253	1,690	1,019	64	134	938	106	3,413
18-Aug	142	98	624	299	348	27	31	316	37	778
21-Sep	68	48	233	131	126	6	8	90	38	299
21-Oct	88	102	22	28	6	3	4	4	3	198
12-Nov	16	4	0	0	0	0	0	0	0	14
16-Dec	29	7	6	6	3	3	0	0	0	33
SE Eastern Sector Mean										
18-Feb	4,421	0	0	0	0	0	0	0	0	4,421
10-Mar	3,476	28	13	13	0	0	0	0	0	3,486
16-Apr	10,831	6,090	315	315	0	0	0	0	0	16,493
2-Jun	2,719	5,187	3,529	2,751	916	68	107	347	638	9,389
23-Jun	3,307	1,706	3,414	1,935	1,569	34	55	1,313	293	4,063
15-Jul	471	135	1,403	862	746	106	169	535	99	1,627
18-Aug	226	81	675	243	463	36	44	422	72	727
21-Sep	118	71	563	317	254	6	28	216	18	715
21-Oct	20	26	44	45	5	3	4	7	6	59
12-Nov	78	45	27	28	4	0	3	4	0	145
16-Dec	189	33	33	31	4	0	0	4	0	237

Table 9c. Percentage in different classes for *Artemia* sector means (from Table 9a), 2015.

	Instars						Ad Female Ovigery Classification				
	1-7	8-11	Instar %	Adult Total	Adult Males	Adult Female Total	empty	undif	cysts	naup	Ovigerous Female%
Lakewide %											
18-Feb	99.2	0.5	99.7	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
10-Mar	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16-Apr	82.9	16.6	99.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
2-Jun	42.9	31.5	74.5	25.5	20.0	5.5	9.7	11.8	0.0	0.0	11.8
23-Jun	41.3	18.2	59.5	40.5	24.9	15.6	0.7	3.5	83.2	12.5	99.3
15-Jul	10.0	10.5	20.5	79.5	47.8	31.7	3.8	11.1	81.5	3.6	96.2
18-Aug	11.6	6.4	18.0	82.0	45.6	36.5	4.5	5.8	80.7	9.0	95.5
21-Sep	18.2	9.3	27.5	72.5	40.5	32.0	1.2	5.9	85.0	7.8	98.8
21-Oct	27.0	36.8	63.7	36.3	31.5	4.8	10.0	25.0	50.0	15.0	90.0
12-Nov	59.5	22.8	82.3	17.7	15.8	1.9	0.0	33.3	66.7	16.7	116.7
16-Dec	82.4	8.8	91.2	8.8	7.7	1.1	33.3	0.0	66.7	0.0	66.7
Western Sector %											
18-Feb	99.8	0.1	99.9	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
10-Mar	98.9	0.5	99.4	0.6	0.5	0.1	0.0	0.0	0.0	0.0	0.0
16-Apr	85.7	13.9	99.6	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0
2-Jun	37.0	34.6	71.5	28.5	22.0	6.5	14.8	15.6	0.0	0.0	15.6
23-Jun	42.0	18.0	60.0	40.0	25.6	14.4	0.7	5.7	77.3	16.3	99.3
15-Jul	10.3	13.9	24.2	75.8	47.1	28.7	3.0	10.2	81.9	4.9	97.0
18-Aug	17.7	7.0	24.7	75.3	45.5	29.8	4.5	9.8	81.7	4.1	95.5
21-Sep	17.2	8.7	25.9	74.1	40.0	34.1	1.4	6.8	81.4	10.4	98.6
21-Oct	31.4	39.5	70.9	29.1	25.6	3.6	12.5	25.0	50.0	12.5	87.5
12-Nov	85.0	15.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16-Dec	63.0	22.2	85.2	14.8	11.1	3.7	0.0	0.0	0.0	0.0	0.0
Eastern Sector %											
18-Feb	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10-Mar	99.3	0.5	99.9	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
16-Apr	74.1	25.0	99.1	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0
2-Jun	48.0	28.9	76.9	23.1	18.4	4.7	0.0	0.0	0.0	0.0	0.0
23-Jun	40.4	18.6	59.0	41.0	23.9	17.1	0.8	1.2	89.8	8.2	99.2
15-Jul	9.7	6.6	16.3	83.7	48.6	35.0	4.6	11.9	81.1	0.0	93.0
18-Aug	8.1	6.0	14.1	85.9	45.6	40.3	4.5	4.2	80.3	11.1	95.5
21-Sep	18.8	9.8	28.6	71.4	40.8	30.6	1.1	5.2	87.9	0.0	93.1
21-Oct	21.9	33.7	55.6	44.4	38.3	6.1	8.3	25.0	50.0	0.0	75.0
12-Nov	55.8	23.9	79.7	20.3	18.1	2.2	0.0	33.3	66.7	0.0	100.0
16-Dec	84.6	7.3	91.9	8.1	7.3	0.8	0.0	0.0	100.0	0.0	100.0

Table 10. Lakewide *Artemia* instar abundance analysis, 2015.

	Instars									
	1	2	3	4	5	6	7	8-11	Adults	Total
Mean:										
18-Feb	5315	4051	178	54	0	32	0	59	38	9728
10-Mar	6884	9931	294	11	0	86	24	3	5	17239
16-Apr	2058	11693	11038	17143	11003	12682	12199	18166	471	96453
2-Jun	5404	15269	1058	1311	391	368	414	20121	16051	60385
23-Jun	1886	14211	1288	322	0	0	46	10440	22627	50819
15-Jul	130	821	756	194	0	0	0	2830	19338	24069
18-Aug	86	308	124	146	108	70	16	546	5963	7368
21-Sep	57	149	84	108	43	59	35	262	1920	2717
21-Oct	43	49	16	30	22	16	14	262	232	683
12-Nov	14	19	11	24	5	5	5	19	19	122
16-Dec	76	41	14	5	5	8	3	14	8	173
Standard error of the mean:										
18-Feb	2413	3213	71	11	0	56	21	3	3	5662
10-Mar	794	1020	99	20	0	21	0	25	22	1484
16-Apr	489	3850	5546	8188	5335	6400	4927	6711	302	39387
2-Jun	1259	1739	333	437	148	227	230	4733	3418	8764
23-Jun	424	2123	263	172	0	0	46	871	2399	3391
15-Jul	51	295	119	64	0	0	0	888	1692	2816
18-Aug	29	96	27	21	27	22	11	87	1009	1050
21-Sep	15	41	14	30	15	29	20	66	344	446
21-Oct	31	12	9	14	9	10	9	86	344	446
12-Nov	8	8	6	8	3	3	5	6	9	32
16-Dec	22	18	14	5	5	6	3	7	6	59
Percentage in different age classes:										
18-Feb	39.9	57.6	1.7	0.1	0.0	0.5	0.1	0.0	0.0	100.0
10-Mar	54.6	41.6	1.8	0.6	0.0	0.3	0.0	0.6	0.4	100.0
16-Apr	2.1	12.1	11.4	17.8	11.4	13.1	12.6	18.8	0.5	100.0
2-Jun	8.9	25.3	1.8	2.2	0.6	0.6	0.7	33.3	26.6	100.0
23-Jun	3.7	28.0	2.5	0.6	0.0	0.0	0.1	20.5	44.5	100.0
15-Jul	0.5	3.4	3.1	0.8	0.0	0.0	0.0	11.8	80.3	100.0
18-Aug	1.2	4.2	1.7	2.0	1.5	1.0	0.2	7.4	80.9	100.0
21-Sep	2.1	5.5	3.1	4.0	1.6	2.2	1.3	9.6	70.7	100.0
21-Oct	6.3	7.1	2.4	4.3	3.2	2.4	2.0	38.3	34.0	100.0
12-Nov	11.1	15.6	8.9	20.0	4.4	4.4	4.4	15.6	15.6	100.0
16-Dec	43.8	23.4	7.8	3.1	3.1	4.7	1.6	7.8	4.7	100.0

Table 11. *Artemia* biomass summary, 2015.

	Mean Biomass		
Date	Lakewide	Western Sector	Eastern Sector
18-Feb	0.81	0.68	0.95
10-Mar	1.71	0.70	2.72
16-Apr	10.1	13.7	6.39
2-Jun	32.3	39.6	24.9
23-Jun	14.1	12.9	15.2
15-Jul	15.2	16.4	14.0
18-Aug	6.78	4.91	8.7
21-Sep	3.08	2.80	3.36
21-Oct	0.43	0.42	0.44
12-Nov	0.27	0.22	0.32
16-Dec	0.26	0.22	0.31

Table 12. *Artemia* fecundity summary, 2015.

	#eggs/brood mean	#eggs/brood SE	%cysts	%indented	Female Length Mean	Female Length SE	n
Lakewide Mean:							
2-Jun	42.5	1.0	100.0	44.3	9.7	0.09	7
23-Jun	36.9	1.3	84.3	41.4	12.2	1.52	6
15-Jul	28.2	1.5	98.6	55.7	11.2	1.36	7
18-Aug	39.1	1.8	98.6	55.7	10.0	0.13	7
21-Sep	56.8	2.8	92.9	54.3	9.9	0.11	7
Western Sector Mean:							
2-Jun	41.0	1.6	57.1	18.6	9.6	0.14	4
23-Jun	36.6	1.5	42.9	21.4	10.4	0.16	3
15-Jul	26.5	1.5	57.1	31.4	12.2	2.38	4
18-Aug	40.0	2.4	57.1	27.1	9.9	0.17	4
21-Sep	59.5	3.9	54.3	32.9	9.9	0.13	4
Eastern Sector Mean:							
2-Jun	44.6	1.0	42.9	25.7	9.9	0.11	3
23-Jun	37.1	2.2	41.4	20.0	14.0	3.28	3
15-Jul	30.4	2.8	41.4	24.3	10.0	0.20	3
18-Aug	37.9	3.0	41.4	28.6	10.2	0.22	3
21-Sep	52.9	3.8	38.6	21.4	10.0	0.21	3

"n" represents number of stations sampled. 10 individuals were sampled at each station with the exception of 9 individuals on June 23rd at station 1 due to undifferentiated egg types.

Table 13. Summary Statistics of Adult *Artemia* Abundance from 1 May through 30 November, 1979-2015.

Year	Mean	Median	Peak	Centroid
1979	14,118	12,286	31,700	216
1980	14,643	10,202	40,420	236
1981	32,010	21,103	101,670	238
1982	36,643	31,457	105,245	252
1983	17,812	16,314	39,917	247
1984	17,001	19,261	40,204	212
1985	18,514	20,231	33,089	218
1986	14,667	17,305	32,977	190
1987	23,952	22,621	54,278	226
1988	27,639	25,505	71,630	207
1989	36,359	28,962	92,491	249
1990	20,005	16,775	34,930	230
1991	18,129	19,319	34,565	226
1992	19,019	19,595	34,648	215
1993	15,025	16,684	26,906	217
1994	16,602	18,816	29,408	212
1995	15,584	17,215	24,402	210
1996	17,734	17,842	34,616	216
1997	14,389	16,372	27,312	204
1998	19,429	21,235	33,968	226
1999	20,221	21,547	38,439	225
2000	10,550	9,080	22,384	210
2001	20,031	20,037	38,035	209
2002	11,569	9,955	25,533	200
2003	13,778	12,313	29,142	203
2004	32,044	36,909	75,466	180
2005	17,888	15,824	45,419	192
2006	21,518	20,316	55,748	186
2007	18,826	17,652	41,751	186
2008	11,823	12,524	27,606	189
2009	25,970	17,919	72,086	181
2010	14,921	7,447	46,237	191
2011	21,343	16,893	48,918	194
2012	16,324	11,302	53,813	179
2013	26,033	31,275	54,347	196
2014	14,459	7,894	48,009	194
2015	8,527	6,035	22,627	186
Mean	19,327	17,947	45,133	209
Min	8,527	6,035	22,384	179
Max	36,643	36,909	105,245	252

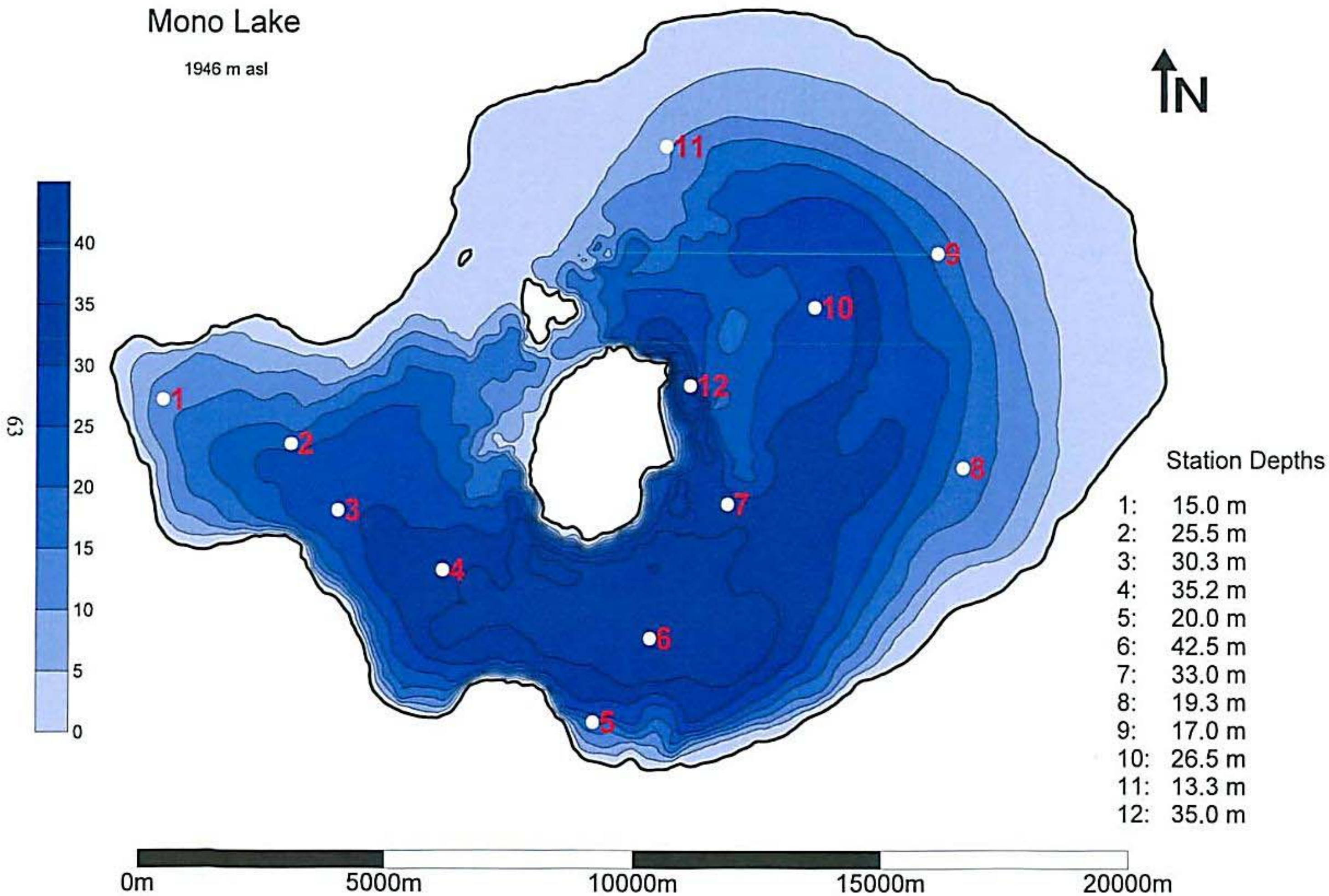

Figure 1. Sampling Stations at Mono Lake and Associated Station Depths.

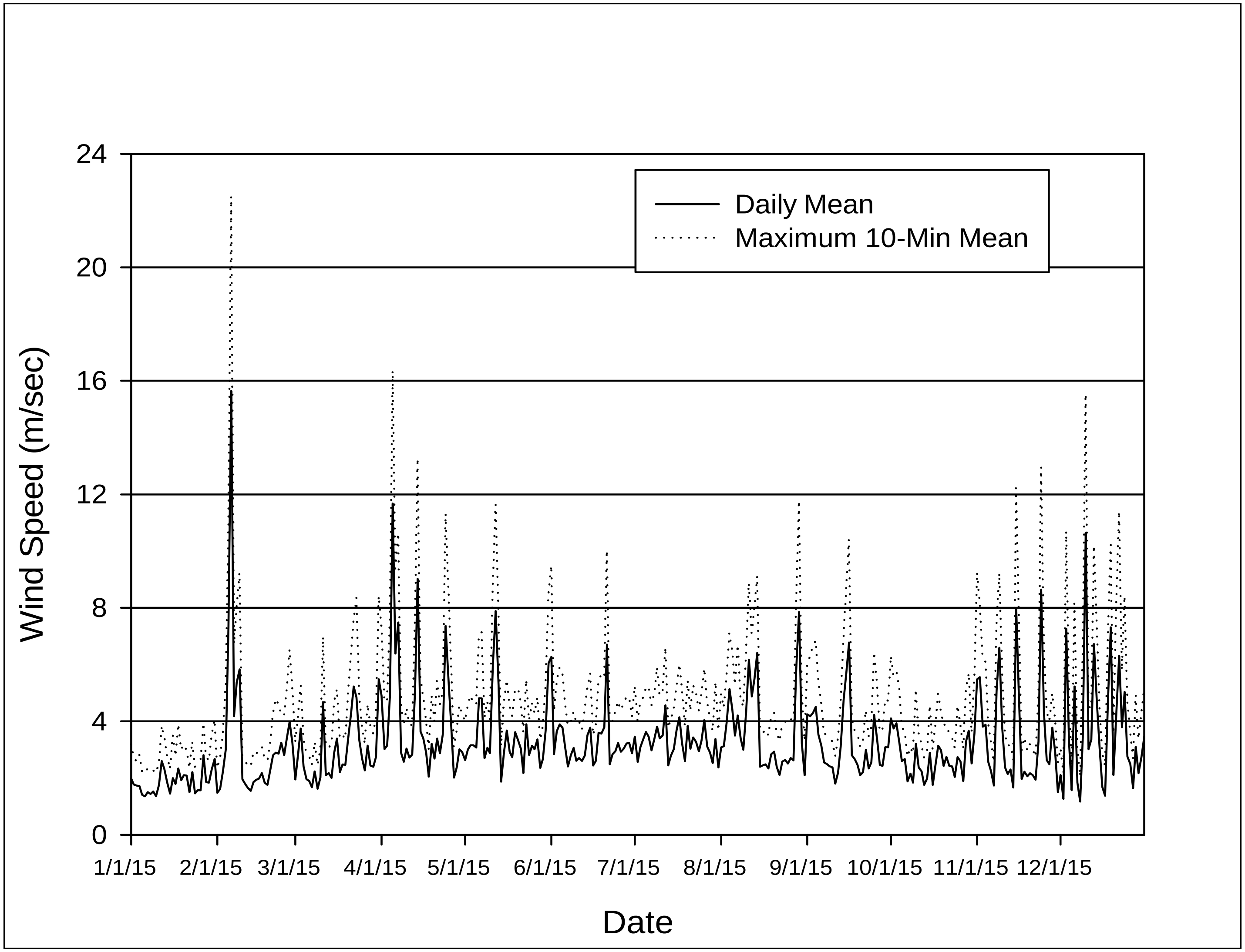

Figure 2. Mean daily wind speed and mean maximum 10-minute wind speed Paoha Island, January 1st- December 31st, 2015.

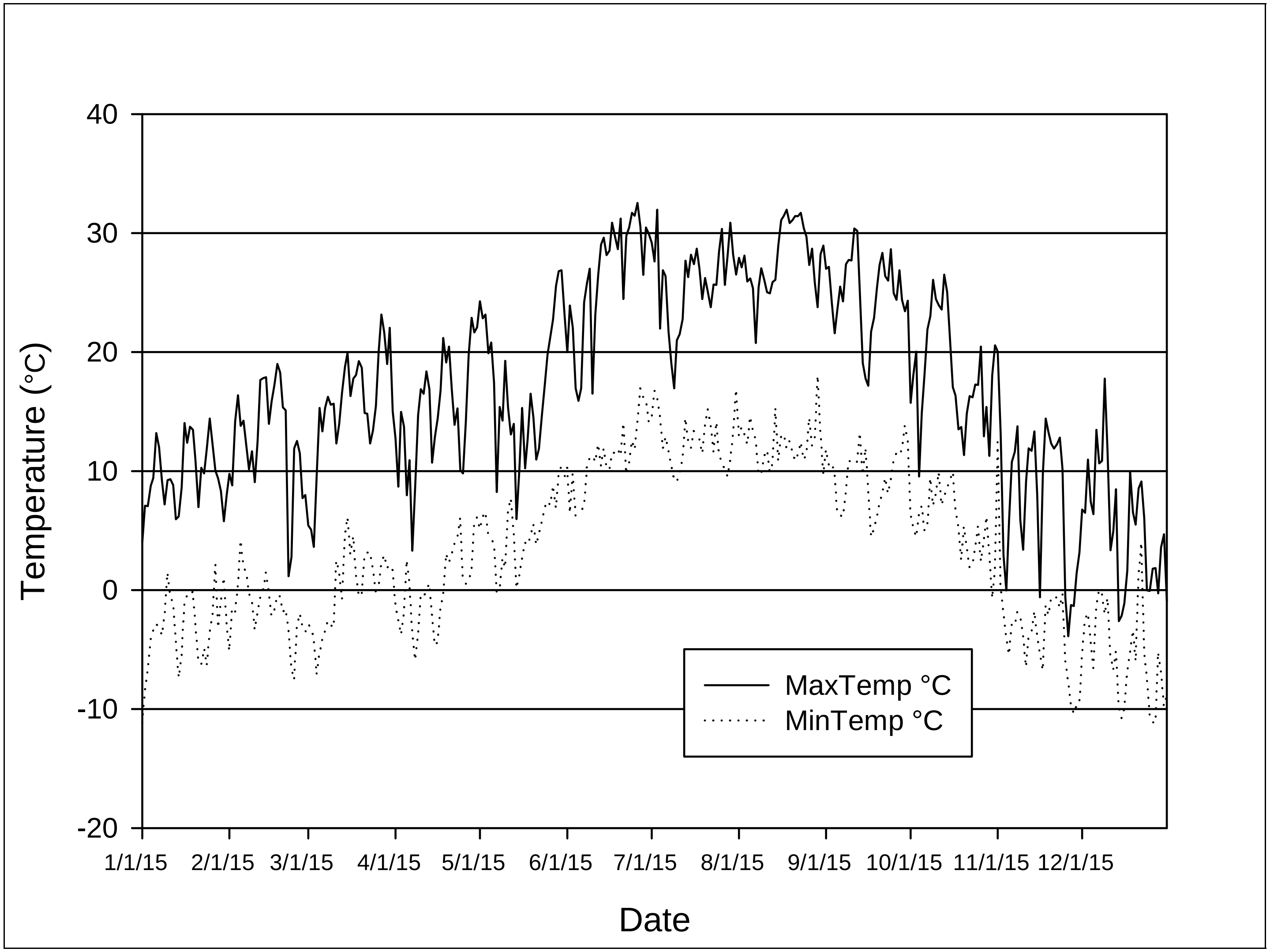

Figure 3. Minimum and maximum daily temperature (°C) as recorded at Paoha Island, January 1st- December 31st, 2015.

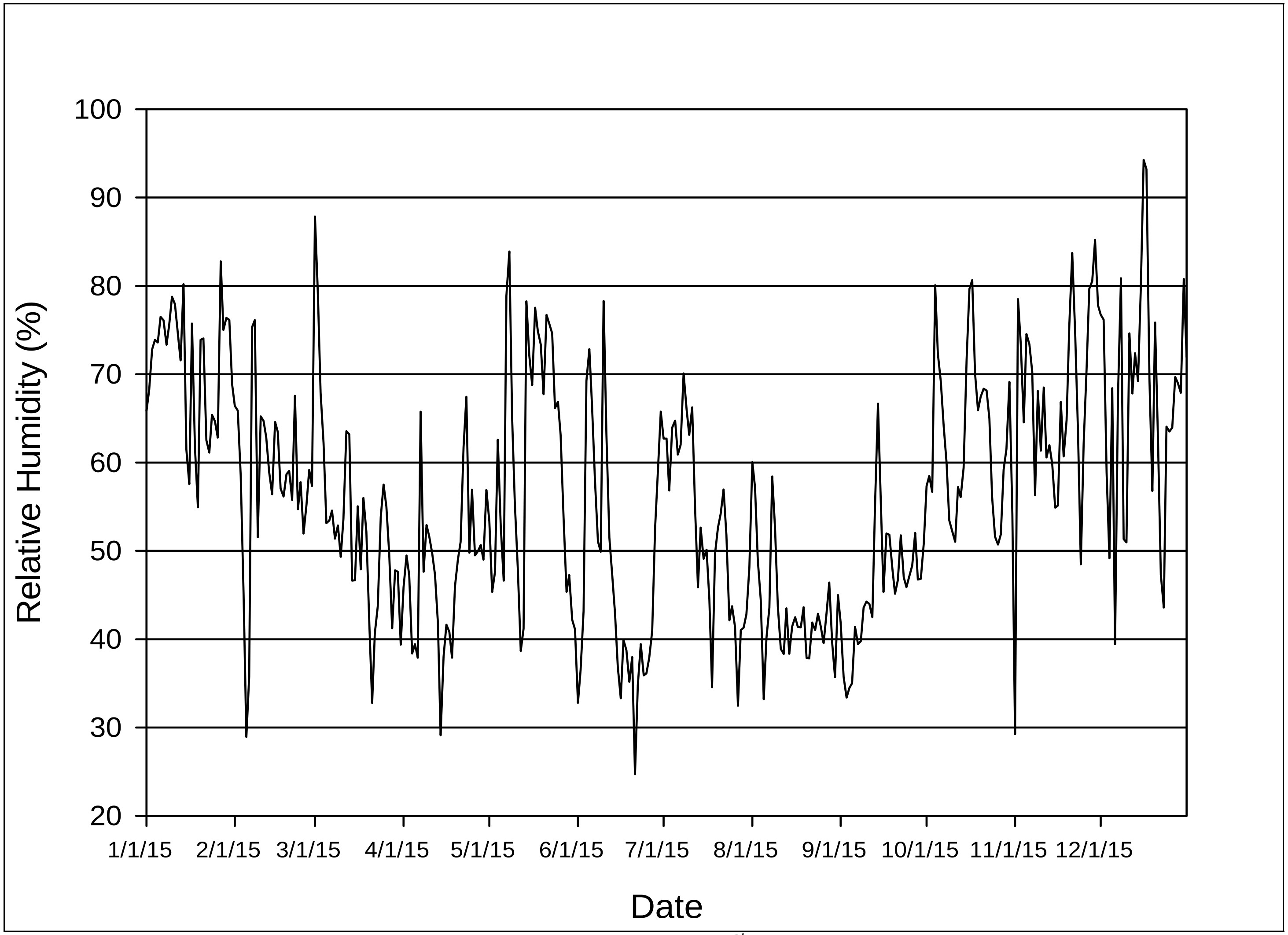

Figure 4. Mean relative humidity (%) – Paoha Island, January 1st- December 31st, 2015.

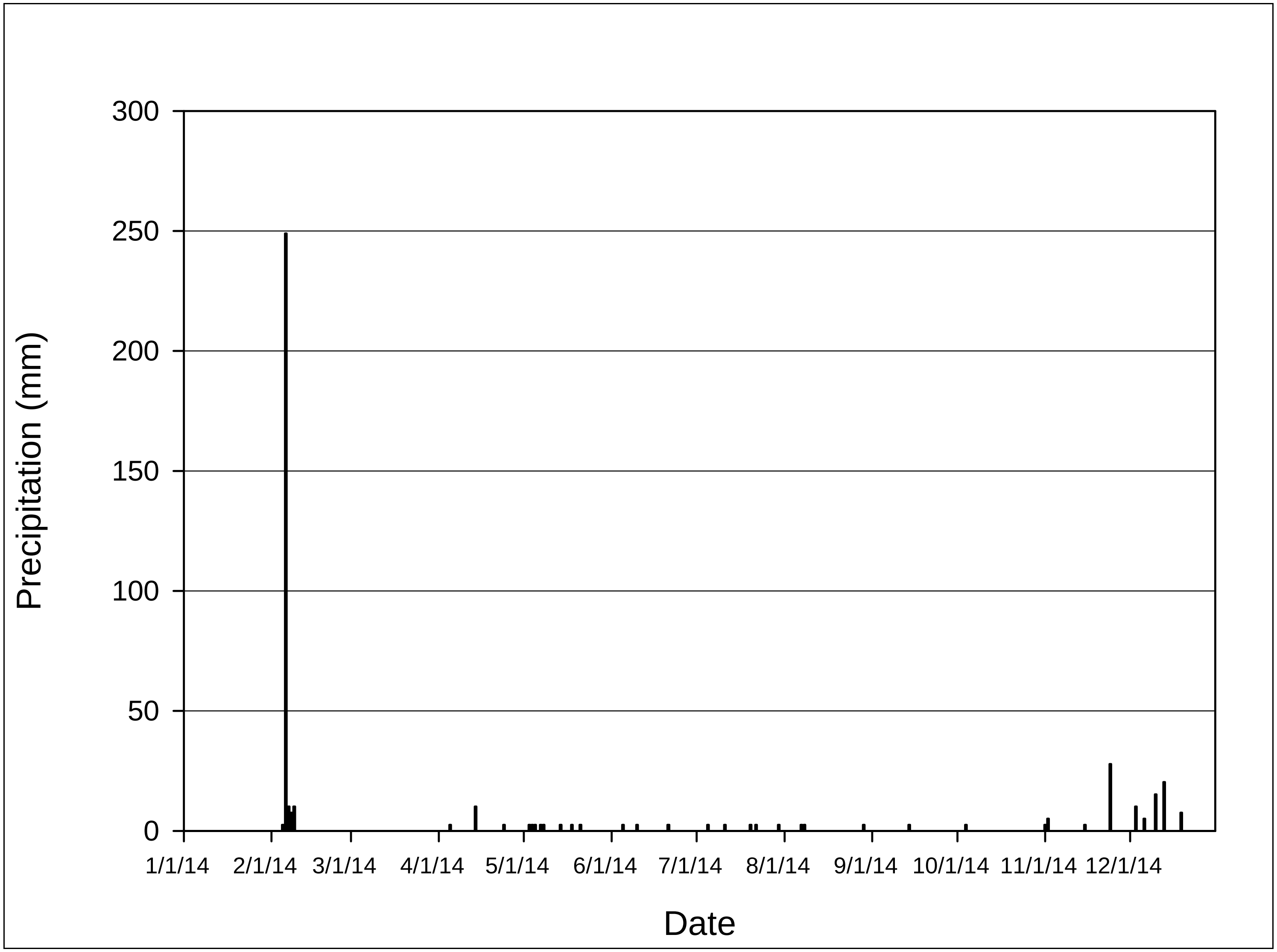

Figure 5. Precipitation (mm) at Paoha Island, Mono Lake, 2015.

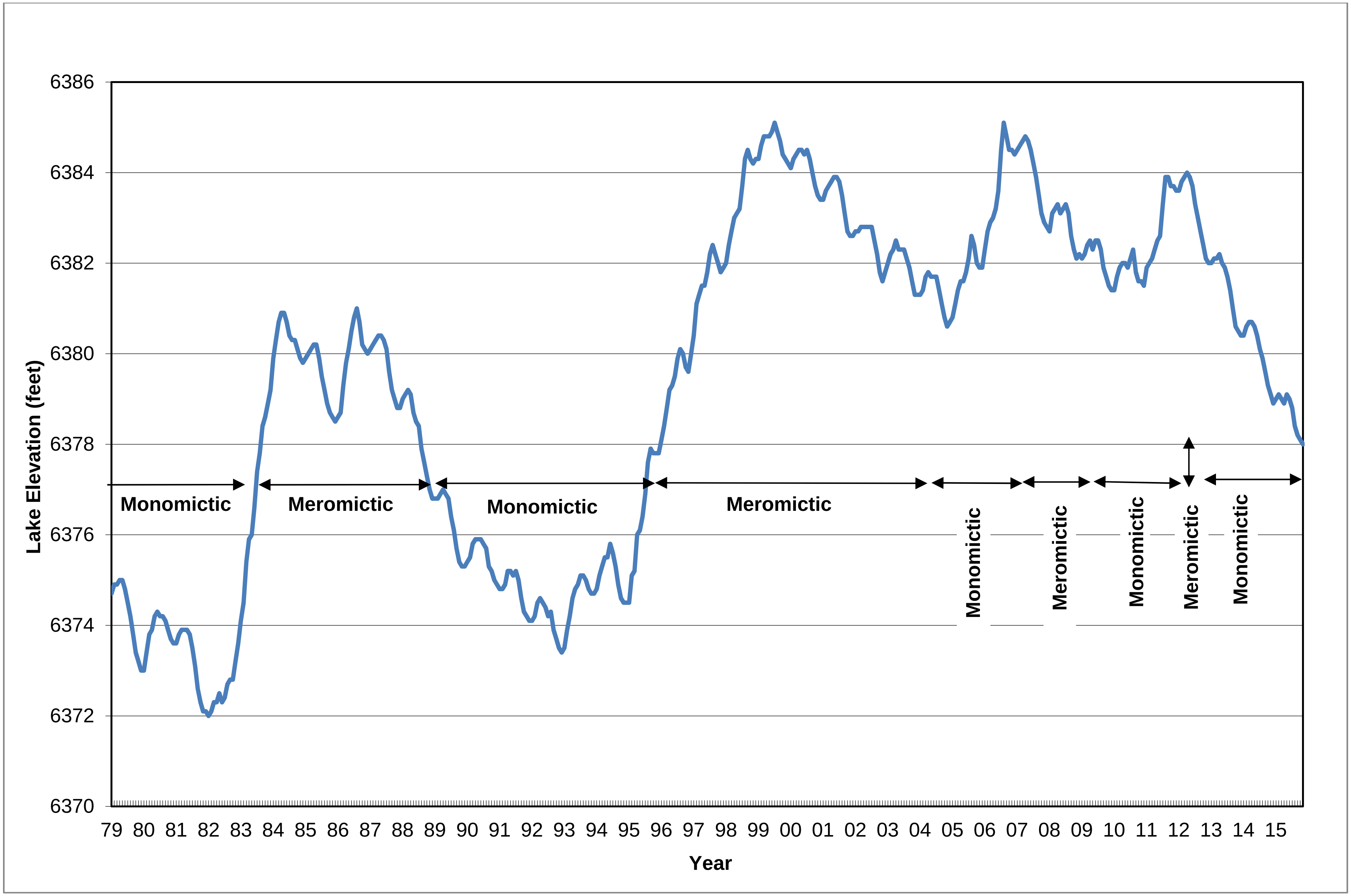

Figure 6. Surface elevation of Mono Lake and mixing regime, 1979-2015 (data ends on calendar year).

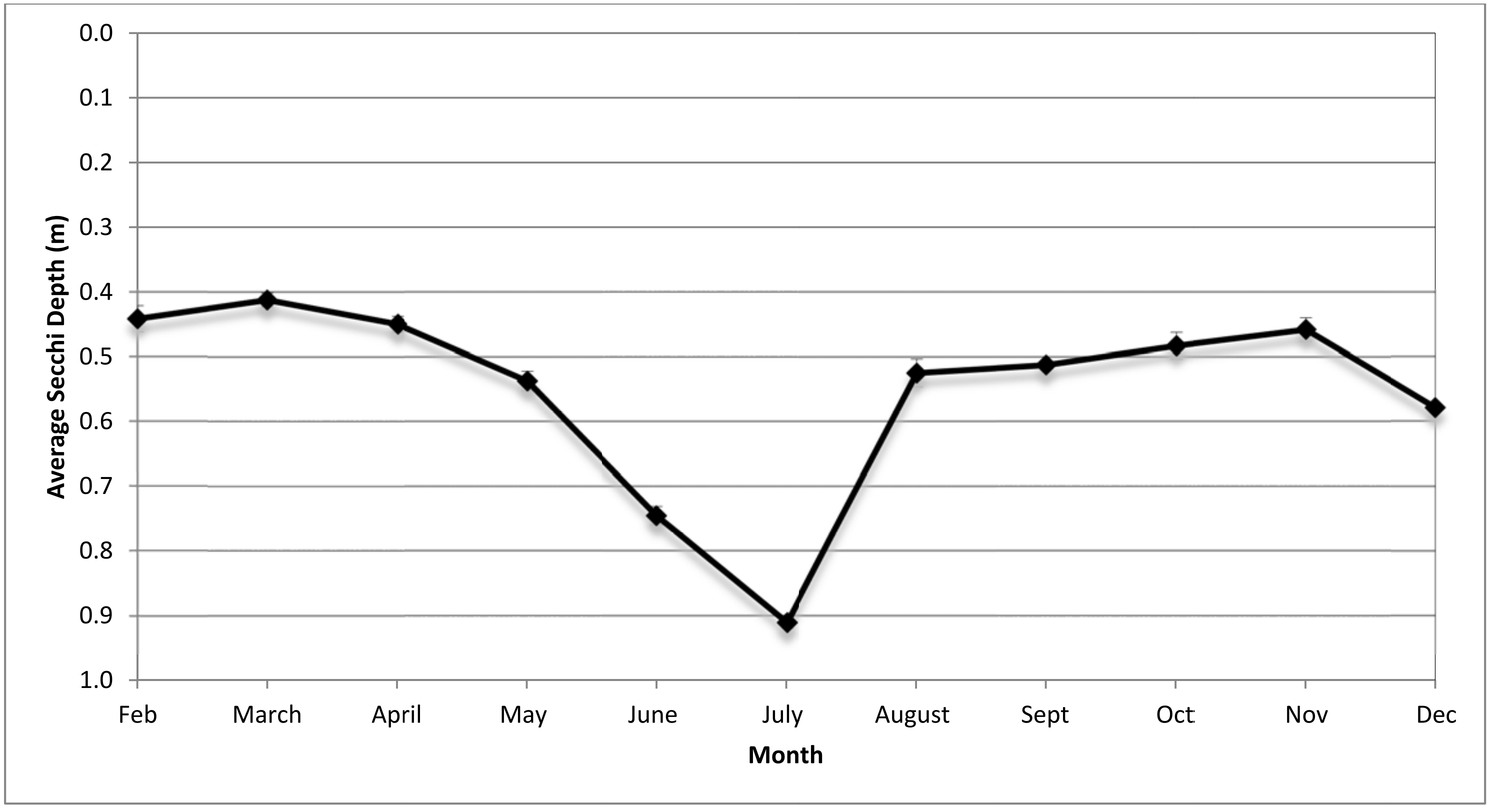

Figure 7. Secchi depths (meters) and standard error, 2015.

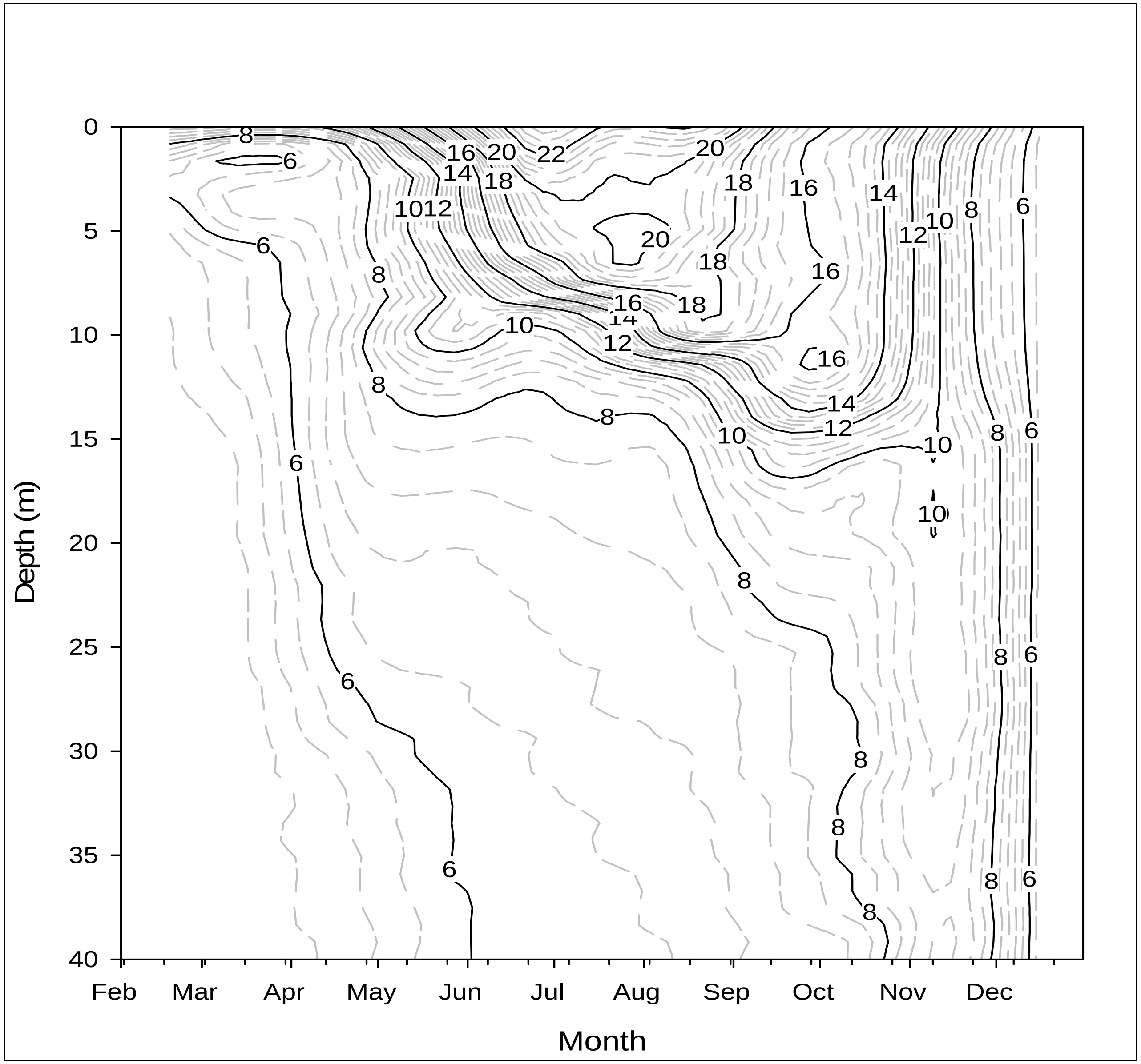

Figure 8. Temperature profiles at Station 6, February to December 2015.

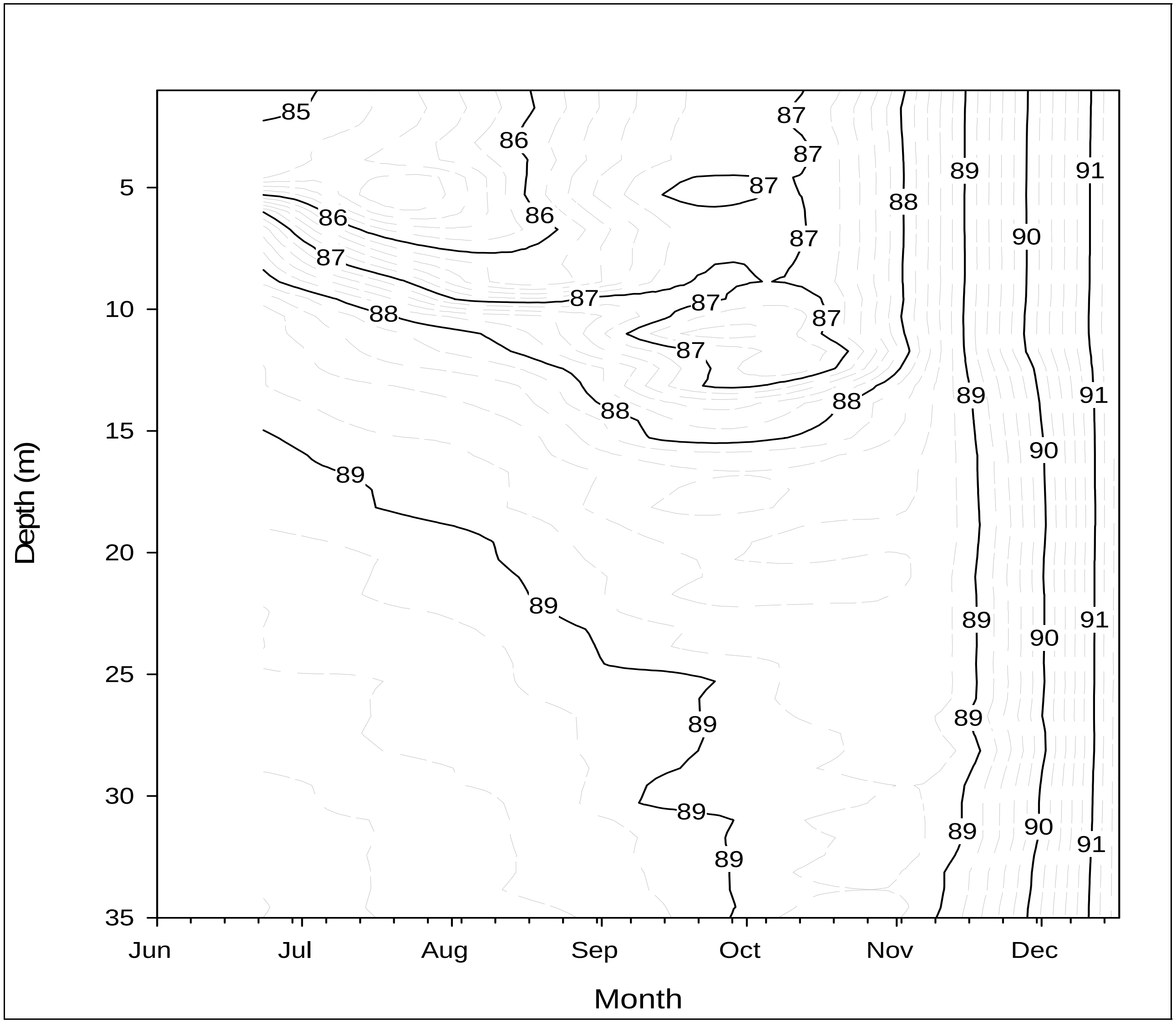

Figure 9. Conductivity (mS/cm) profiles at Station 6, June-December, 2015.

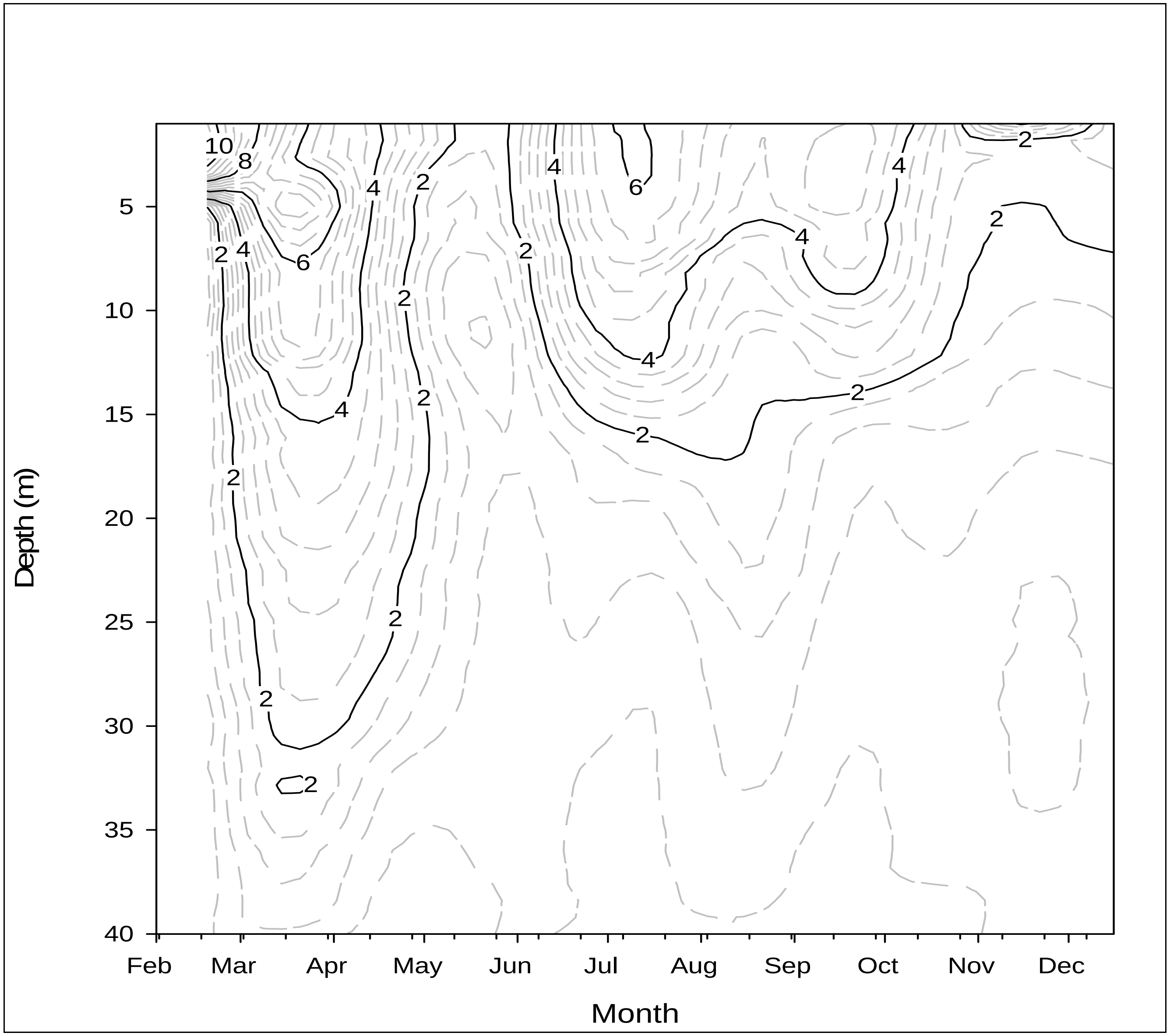

Figure 10. Dissolved oxygen profiles at Station 6, February – December 2015.

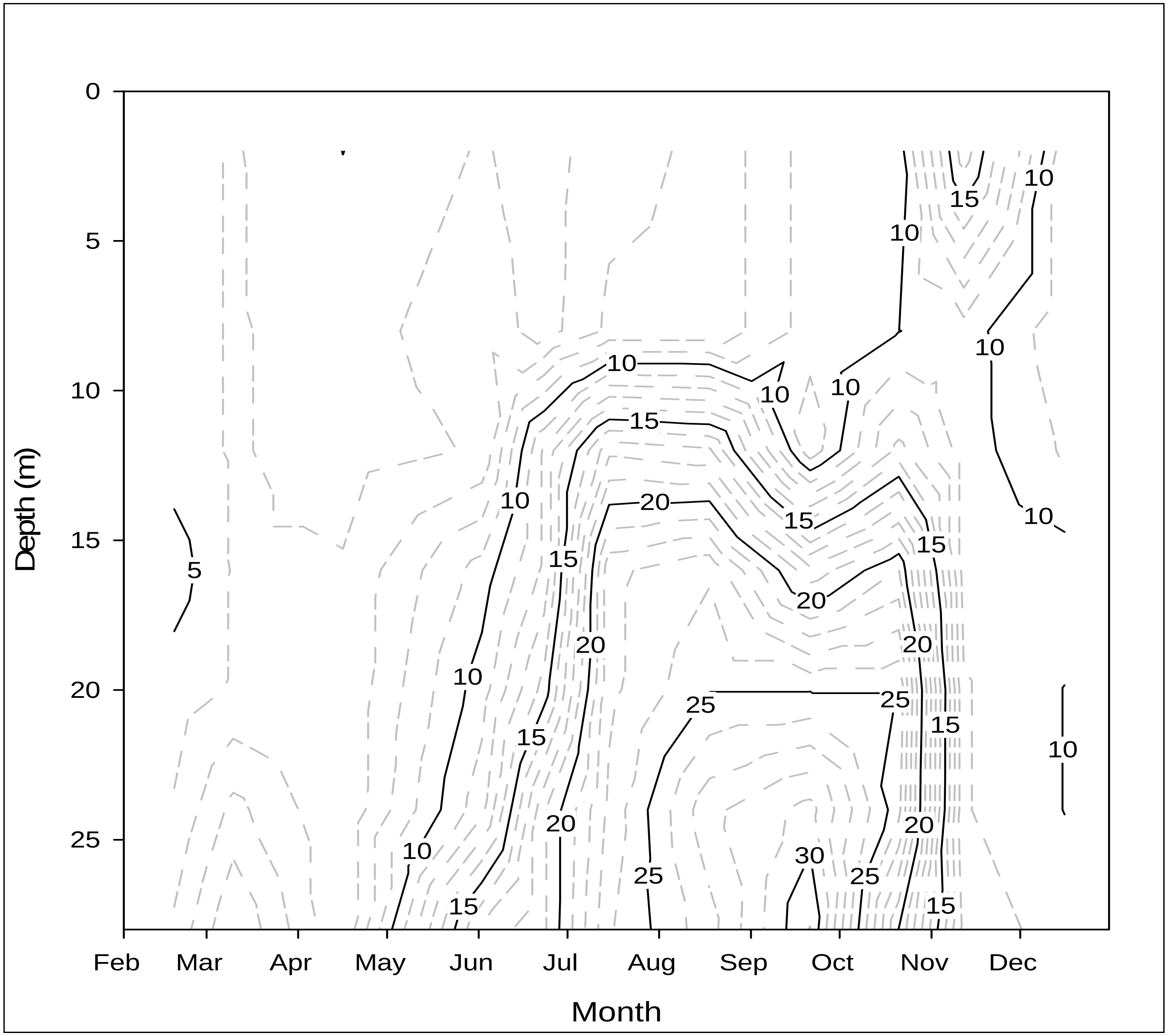

Figure 11. Ammonium profiles Station 6, February – December 2015.

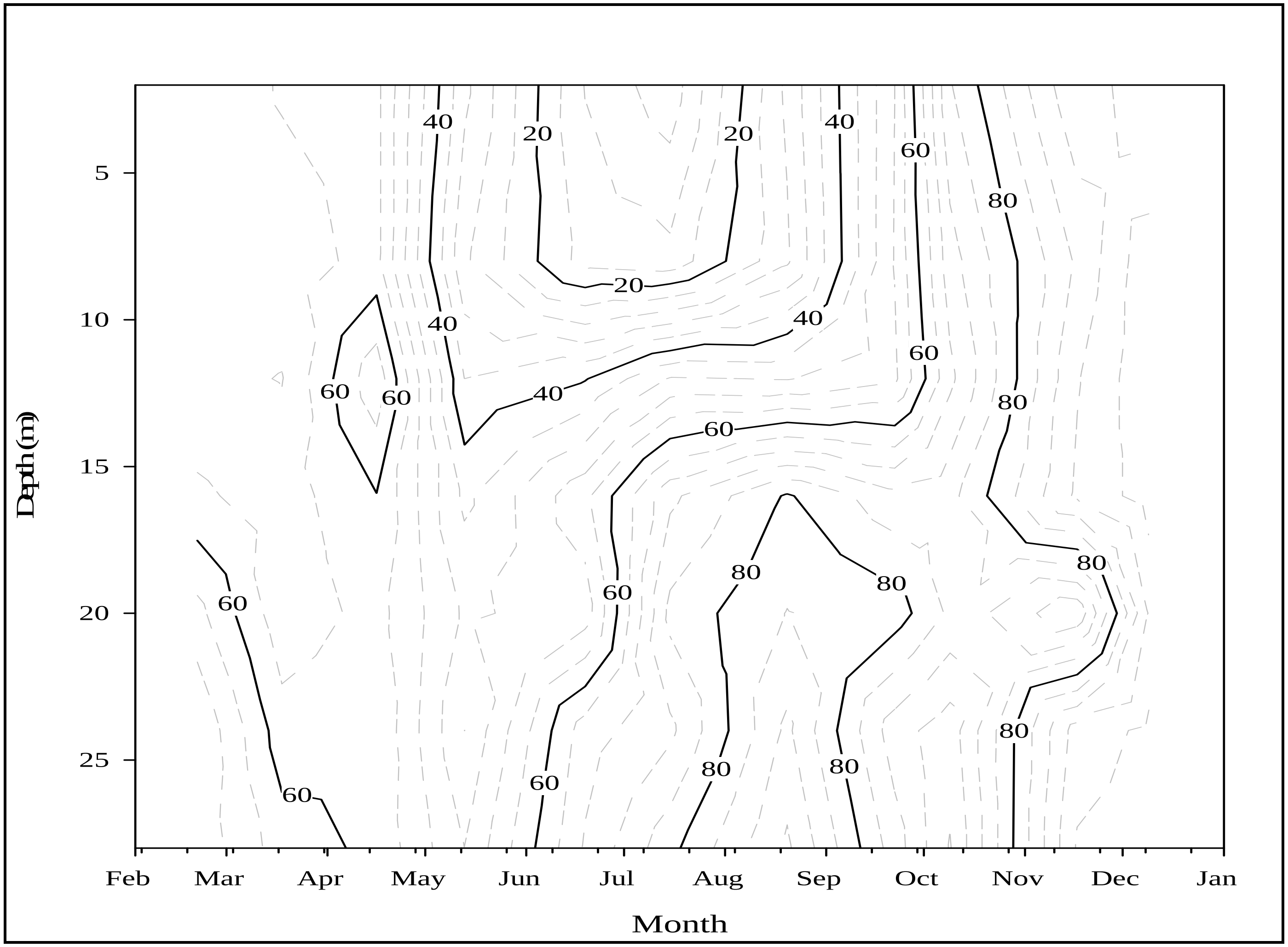

Figure 12. Chlorophyll *a* profiles at Station 6, February – December 2015.

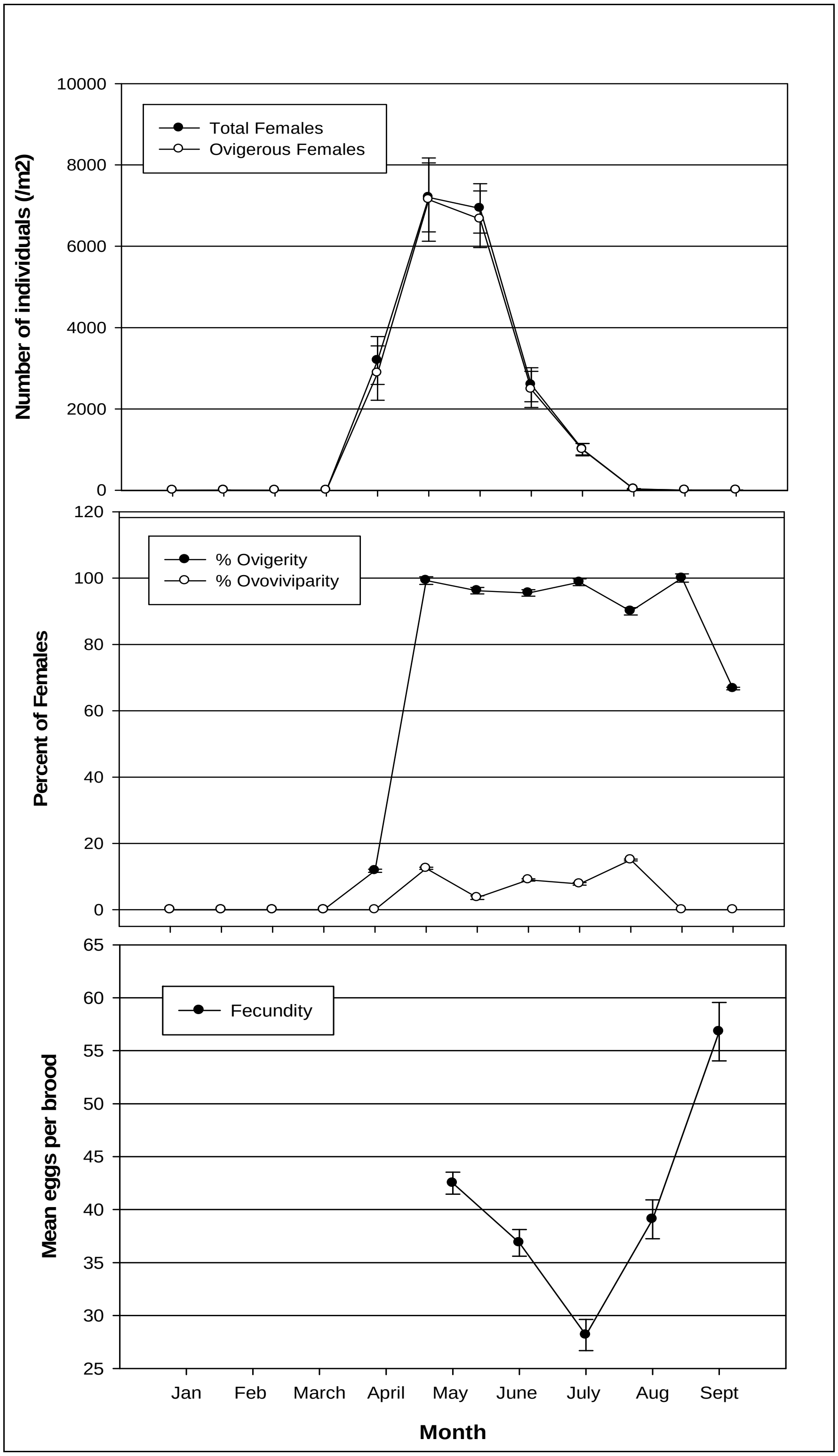

Figure 13. *Artemia* reproductive parameter and fecundity, May-September 2015.

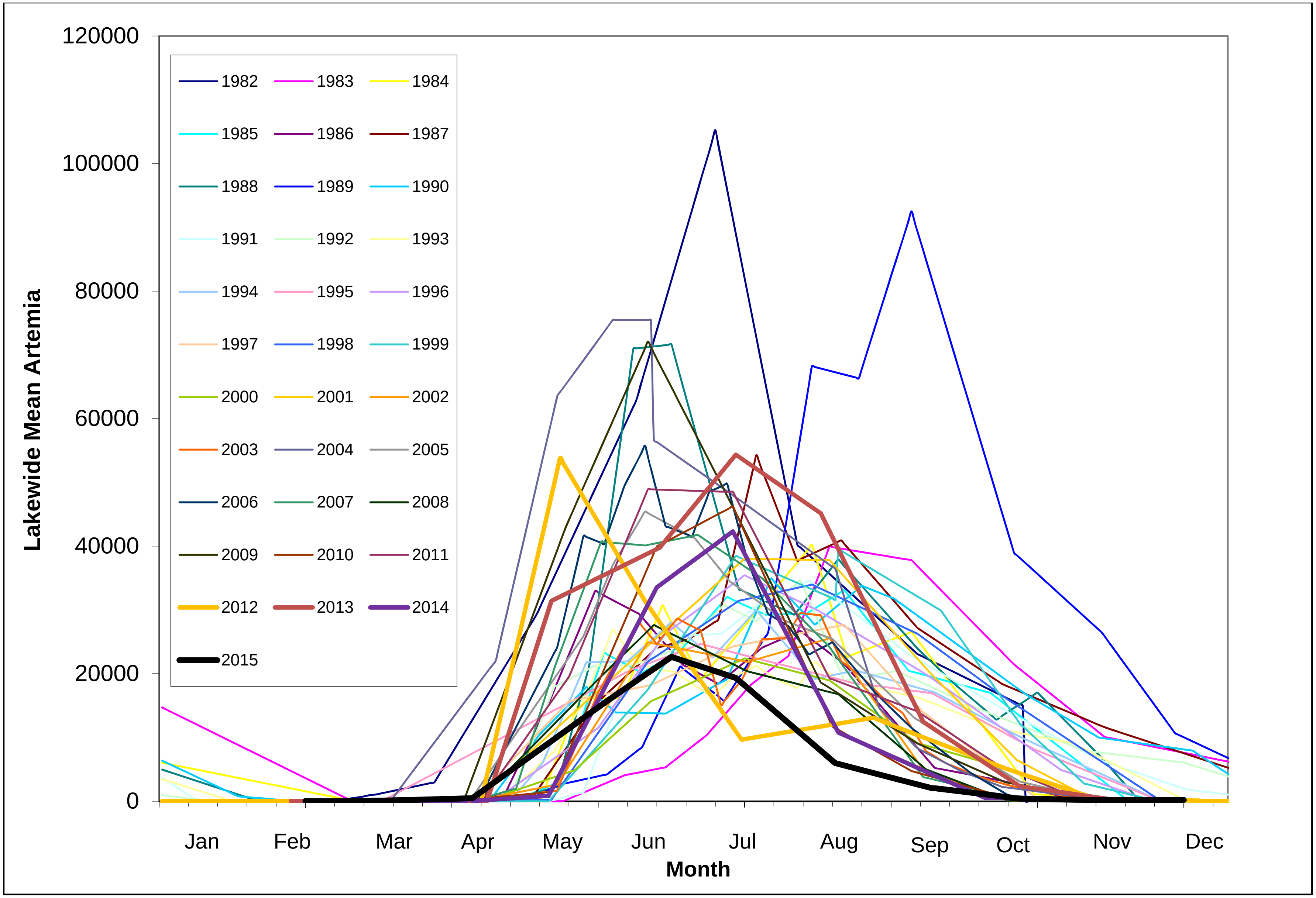

Figure 14. Mean lakewide *Artemia* abundance 1982-2015.

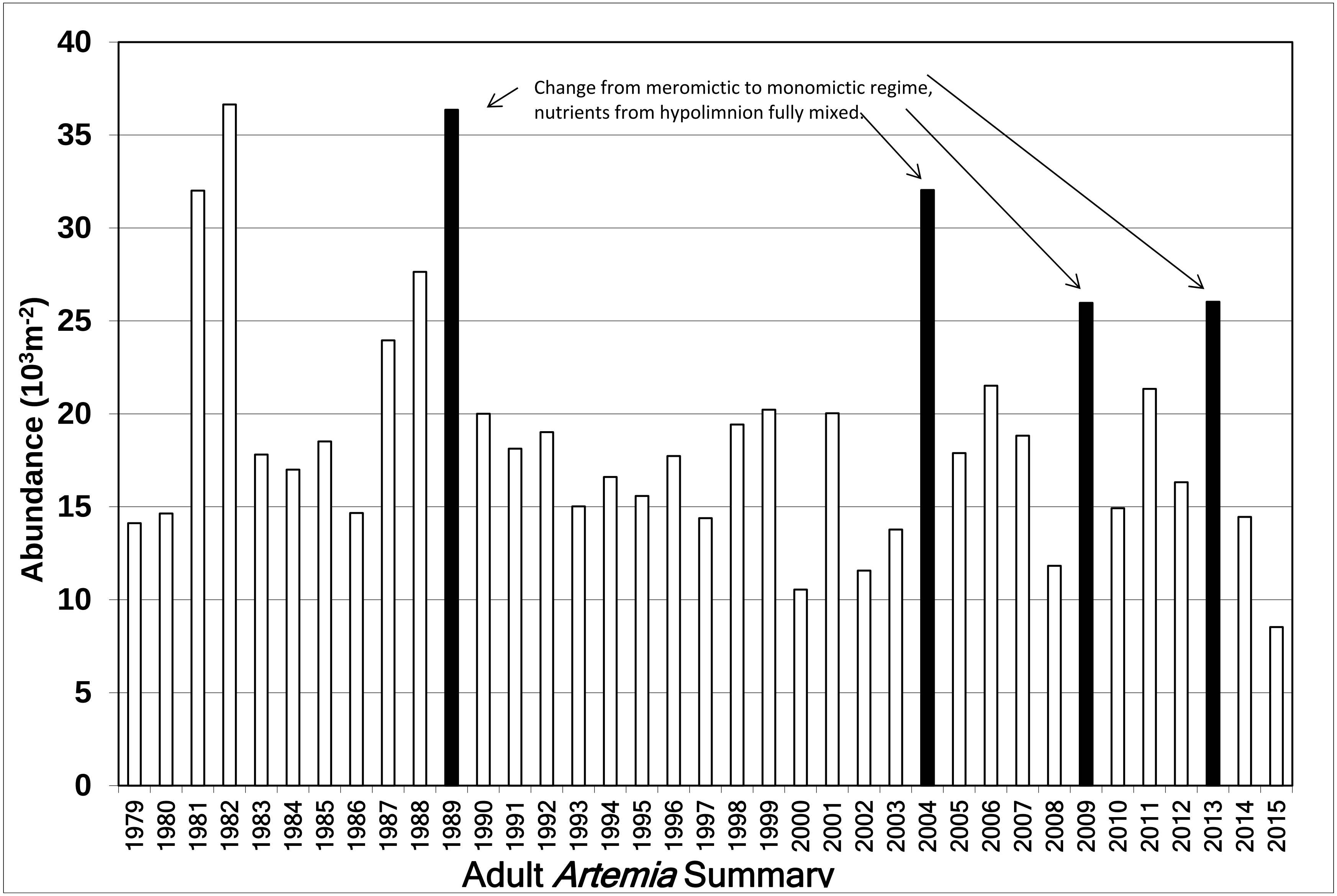

Figure 15. Mean adult *Artemia* abundance from 1979-2015 (May-November), indicating years subsequent to onset of monomixis.

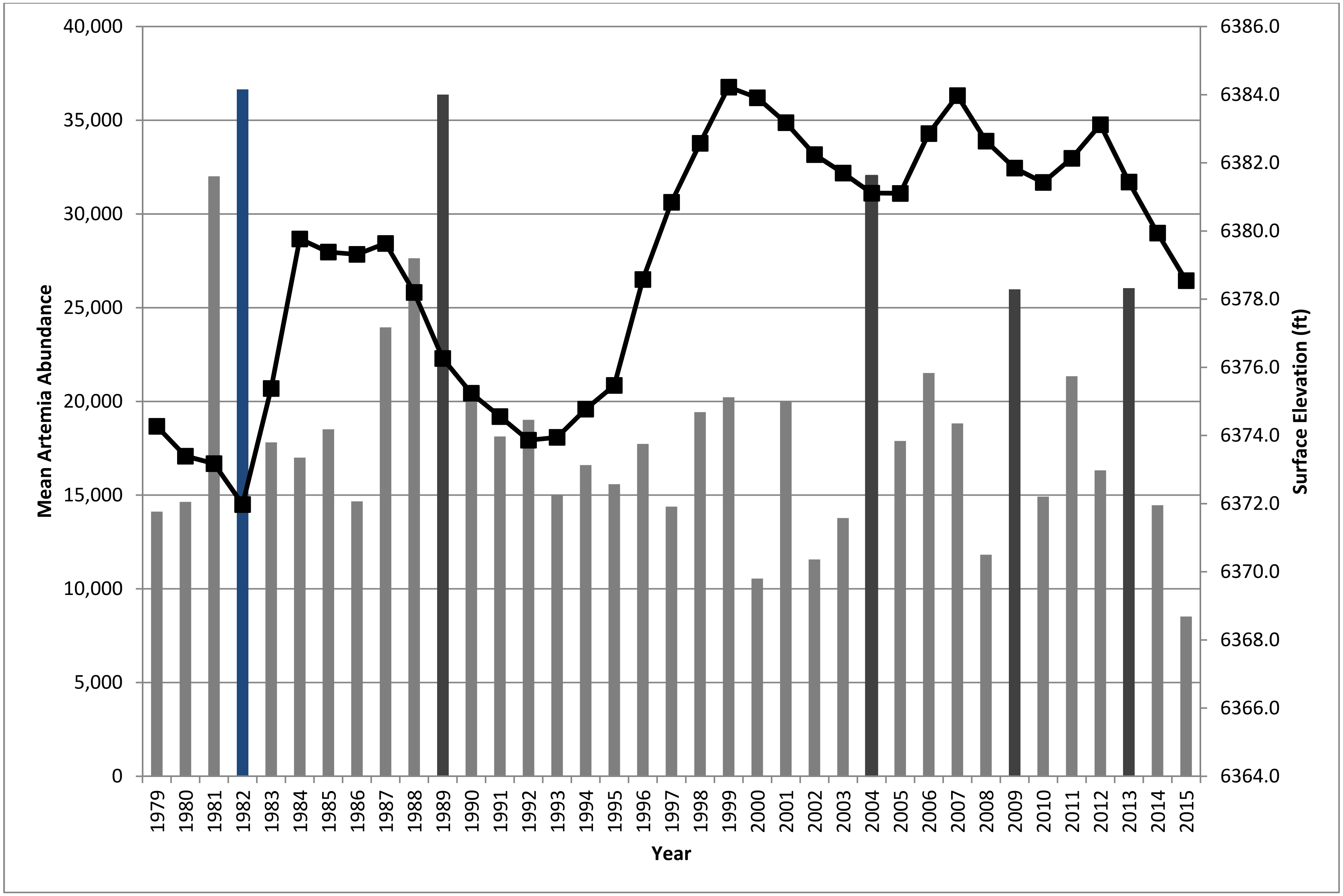

Figure 16. Mean surface elevation of Mono Lake from 1979-2015 denoted by black line. Gray bars indicate mean shrimp abundance per year (May-November). Dark gray bars indicate years subsequent to shift from meromictic to monomictic regime.

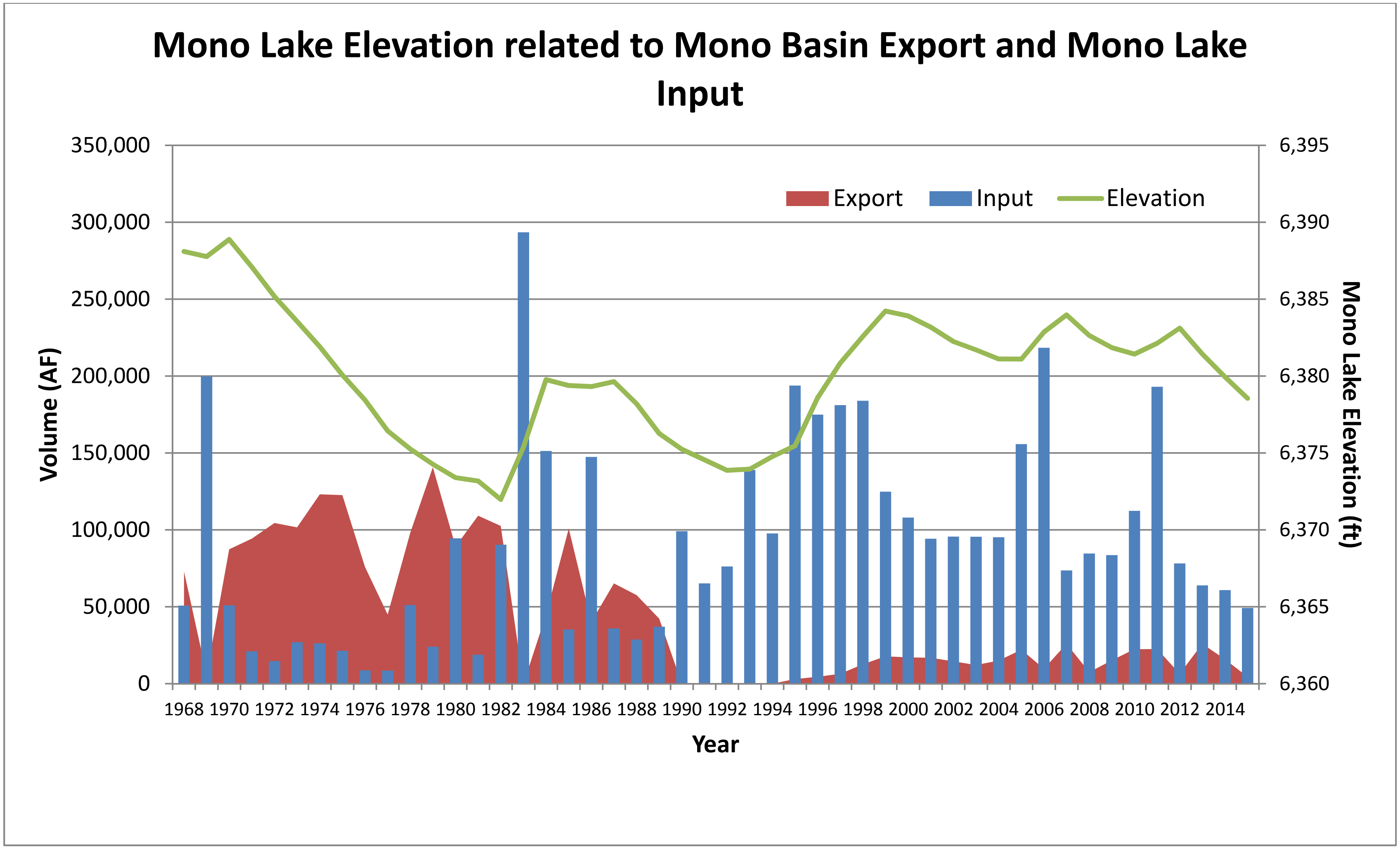

Figure 17. Annual export of water from Mono Lake tributaries, input to Mono Lake and surface elevation from 1963-2015 reported in acre feet per water year (April-March). Data from LADWP database.