FLATHEAD LAKE JOURNAL

(Formerly the Yellow Bay Journal)

A publication of the Flathead Lake Biological Station, University of Montana

Jim Craft collecting zooplankton

STATE OF THE LAKE

Synopsis by B. K. Ellis

The Flathead Lake Biological Station (FLBS) has carefully documented the status of water quality in Flathead Lake and its tributaries since the Station was founded in 1899. In the early days, studies were periodic. Since 1977, measures have been obtained about monthly by the Biological Station using standardized protocols. These studies have been the technical background for development of a Total Maximum Daily Load (TMDL) allocation for the purpose of managing nutrient loads reaching Flathead Lake.

Based on Station research, the Flathead Basin Commission (FBC) recommended the following interim targets for protection of water quality in Flathead Lake: 1) no increase in biomass of lakeshore periphyton, 2) no measurable blooms of *Anabaena flos-aquae* (or other pollution algae), 3) no declining trend in oxygen concentrations in the hypolimnion, and 4) average annual concentrations of the following variables in the photic zone of the Midlake Deep site in Flathead Lake will not exceed the values indicated: chlorophyll *a*: 1.0 µg/L (1 microgram per liter) and primary production: 80 g C m^{-2} yr^{-1} (80 grams of carbon per square meter per year).

The first target for the protection of water quality is not being met. There is a significantly increasing trend in periphyton biomass (algae on rock surfaces) at the Horseshoe site for the period of record (1999–2013) (Fig. 1). Although there was no significant trend in periphyton biomass at the "B" Beach site for the period of record, biomass in 2013 was statistically significantly higher than measures made in 1988 (i.e., 5.6 versus 1.2 µg cm^{-2}). Hence, our measurements confirm comments from long-time residents that shoreline rocks are coated with more algae in recent years.

No visual evidence of an algal bloom was detected in fall 2012 or summer 2013, but qualitative assessment will have to be confirmed after enumeration of surface phytoplankton samples. Additional funding is warranted to examine possible factors causing toxic blue-

In This Issue...

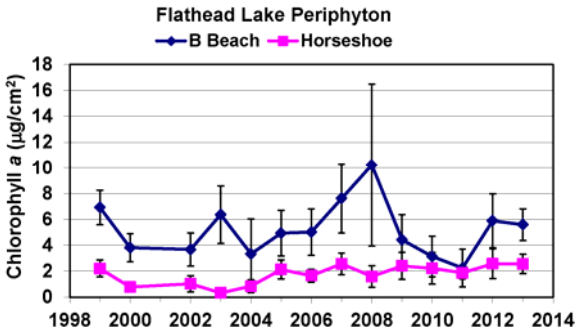

Figure 1. Mean periphyton biomass as chlorophyll *a* (µg cm-2) + 1 standard deviation at 5 m depth in August of each year at the two long-term monitoring sites on Flathead Lake.

(Continued on page 2)

Flathead Lake Research Cruise

You are invited to join Flathead Lake Biological Station researchers for an afternoon cruise on July 14, 3:15–6:15 PM at Flathead Lake Boat Tours, Lakeside Marine, Lakeside. Learn about FLBS ecological and water quality research and enjoy music by 17 Mile while cruising on Flathead Lake in the *Far West.* Appetizers and beverages will be served.

Tickets are $50 per person and proceeds benefit Biological Station Research and Monitoring in the Flathead. Limited seats are available so RSVP soon by emailing Tom Bansak at events@flbs.umt.edu or calling 406-982-3301 x229. i

Summer Seminars June 25 and June 29

The station is hosting two free seminars this month, starting with postdoctoral scientist Shawn Devlin's talk titled "Modeling Flathead Lake: Using 35 Years of Data to Investigate Climate Change, Nutrient Loading and Trophic Interactions" on **Thursday, June 25**.

Chris Frissell, consulting research ecologist and freshwater conservation biologist, will present "Riparian Forests: Ecosystem Science and the Management of Western Watersheds for Freshwater Resource Protection in the Face of Fire" on **Monday, June 29**. **Both lectures will be held from 6 to 7 p.m. in the Elrod Lecture Hall at FLBS**. i

Help conserve natural resources by viewing the Flathead Lake Journal (in color) on the FLBS website at: http://flbs.umt.edu/outreach/fljournal.aspx. To receive new issue alerts via email in lieu of hard copy, call 406-982-3301, send an email to flbs@flbs.umt.edu, or mail a note to FLBS-UM, 32125 Bio Station Lane, Polson MT 59860-6815. Make sure to include an email address and name.

(Continued from page 1)

green *Anabaena* to flourish in certain years to gain insight into conditions favoring growth of this noxious species.

Although there is no significant long-term trend in bottom DO at the Midlake Deep site, the percent saturation of DO dropped to 79% at Midlake Deep and 82% at Midlake North in 2013. Lower DO values continue to occur at the Ross Deep site in Big Arm Bay. In July 2013, DO saturation was only 78% just off the lake bottom. Low oxygen limits habitat for many trout. Oligotrophic lakes like Flathead generally do not exhibit DO saturation values below 90%. The most probable cause would be increased production of algae in that area of the lake. As the algae die and fall into deeper waters, they are fed upon by bacteria. Bacteria then use up oxygen in the breakdown process. Additional analysis of 2012–2013 synoptic data from the Ross Deep area and 2012–2013 data from the automated profilers at the long-term Midlake site (monitored DO and many other water quality variables 4–6 times a day) should provide more insight.

In WY 2013, the average annual chlorophyll *a* concentration slightly exceeded the TMDL target (1.2 µg/L see Fig. 2). Five nutrient variables recommended by the FBC TMDL Technical Committee as targets—total phosphorus, total nitrogen, nitrate + nitrite, ammonium and soluble reactive phosphorus—were measured. Numerous studies have shown both phosphorus and nitrogen stimulate growth of algae in Flathead Lake. Mean midlake concentration of total nitrogen was above the long-term average (Fig. 2). Water year 2013 means for the other analytes (i.e., total phosphorus, soluble reactive phosphorus, nitrate and ammonium nitrogen) were quite similar to long-term (1988–2012) annual means.

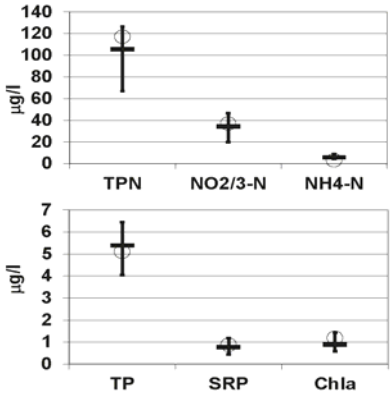

Figure 2. Long-term annual mean (thick bar) and range of annual means (thin bars) for nutrient and chlorophyll *a* concentrations of 0–30 m integrated samples collected from 1988–2012 at the Midlake Deep site on Flathead Lake. Integrated means were calculated for each water year (i.e., Oct. 1–Sept. 30). Integrated mean concentrations for the 2013 water year, Oct. 1, 2012–Sept. 30, 2013, (circles) are also presented for comparison.

Primary productivity is a measure of the ability of the lake to produce algae (Fig. 2). The annual rate of primary production at the Midlake Deep monitoring site in WY 2013 (Fig. 3) exceeded the TMDL target by 36%. With the exception of water years 1994 and 2008, annual primary productivity in Flathead Lake has been at least 10% greater than the FBC target since 1989, and in 1998 exceeded the target by 55%.

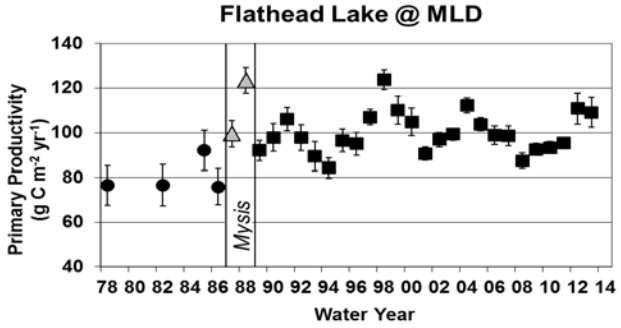

Figure 3. Mean annual pelagic primary productivity (g C m^{-2} yr^{-1}) at Midlake Deep site for Flathead Lake from 1978–2013. Bars represent minimum and maximum yearly estimates.

This target variable requires understanding of food web dynamics and cannot be interpreted independent of those dynamics. We are currently developing a detailed physical-nutrient-food web model for Flathead Lake aimed at understanding the dynamics of food web interactions and the linkages of increasing nitrogen in the catchment and lake response variables, such as primary productivity.

Dramatic alteration of the composition of at least 3 trophic levels (e.g., fish, zooplankton and algae) of the lake food web occurred during the establishment of the opossum shrimp in the mid to late 1980s (Ellis et al., *PNAS USA*, 108, 1070–1075, 2011). This essentially resulted in a lake with a different biological community that has likely altered nutrient cycling. Utilizing the food web model, we will be able to examine changes that have occurred and their effect on the TMDL target parameters.

Maintaining clean, clear water is a quality of life issue for Montana. We cannot know conditions without accurate measurements taken routinely year after year. Government support for monitoring has been drastically reduced during the last decade. An endowed fund to help continue the necessary level of sampling to assess trends in water quality for Flathead waters was established a few years ago. This fund will supplement limited government funding and provide long-term support for water quality monitoring of Flathead Lake and many basin tributaries. Continuing these monitoring efforts is essential to ensure that the Flathead Lake of the future is as spectacular as the one that we enjoy today. i

Next State of the Lake Update on August 18 at Flathead Lakers Annual Meeting

Dr. Jack Stanford, Bierman Professor of Ecology and Director of the Flathead Lake Biological Station, will present the next State of the Lake update on August 18 at the Flathead Lakers Annual Meeting.

POLSON CHAMBER OF COMMERCE AWARD

The Bio Station was voted Polson Chamber of Commerce Natural Resource Business of the Year! Many thanks to the Polson Chamber of Commerce, the businesses and community of Polson, and all of you who voted on our behalf. We are honored to have been selected as the Natural Resource Business of 2014. FLBS Director Jack Stanford accepted the award and enjoyed his time at the lively Polson Chamber's Annual Awards Banquet. i

FLBS Postdoctoral Scientist Shawn Devlin and Flathead Lake: Climate, Nutrients, and Fish

Shawn Devlin, a lake ecologist, joined the Flathead Lake research team at FLBS in 2014 as a postdoc. He is tackling some important questions about the lake using a sophisticated computer model and the extensive dataset collected by researchers at FLBS over the past 35 years. Shawn is investigating how climate change may affect the lake's biogeochemistry and thermal dynamics. He is also studying how nutrient loading and changes in land use may affect primary production and how changes in the lake's fish community may reverberate throughout the food web.

Shawn earned his Ph.D. from Wright State University studying the important role of periphyton (better known as pond scum) in clear water lakes. Shawn then spent three years in Jyvaskyla, Finland taking part in a whole-lake experiment to investigate how fish may regulate greenhouse gas emissions from lakes.

Soon after arriving in Montana to start his new position at the Bio Station, Shawn and his wife Hilary welcomed their third son, now almost a year old and proud to be from Montana! Shawn and his family are thrilled to be in the Flathead Valley and have quickly become part of the community. Hilary is already on board at the Flathead Lakers and Shawn joined the Ferndale Volunteer Fire Department.

Shawn is an avid fly-fisherman and enjoys exploring Montana's famous lakes and rivers as well as hunting, brewing beer, and spending time with his family. The Devlins love spending time outdoors and what a place to do just that! i

Will Deacy Studies the Iconic Kodiak Brown Bear

In 2010, Will Deacy volunteered to assist with a bear project at the National Wildlife Refuge on Kodiak Island, Alaska where Kodiak brown bears instill a reverence for nature. Kodiak Island generally has a healthy and high density brown bear population. During the 2010 field season, US Fish and Wildlife Service biologists conducted an aerial survey in the southwest corner of the Kodiak Refuge and were perplexed when they found a 48% decline in bear population from 2003 to 2010. This piqued Will's interest to further study Kodiak bears. Will said, "I did not foresee this as my PhD focus, but I was compelled to discover what could cause such a dramatic decline. Salmon runs in southwestern Kodiak had been erratic and some observational evidence corresponded to the decline in bear population. But in ecology, oftentimes something that looks very simple turns out to be very complex." Needing a mentor with salmon ecology expertise for studying salmon-bear interaction, Will found an advocate in Dr. Jack Stanford and began his PhD work at the Station in 2012.

Funded by USFWS and FLBS, Will has been working with USFWS biologist Bill Leacock, wildlife ecologist Jonny Armstrong (University of Wyoming) and Professor Stanford to understand what caused the dramatic drop in bear numbers. The researchers devised innovative methods to monitor salmon runs on 11 streams and bear movement across the study site. Will says, "We haven't fully solved the problem of bear declines, however, we've learned a lot about how important salmon are to Kodiak bears and how well bears track salmon across the landscape."

During 2013 and 2014, Will notes they found that bears follow the salmon as they arrive at different times in different spawning or migration sites. Much like wildebeest follow green-up of grasses on the Serengeti in Africa, scientists refer to this pattern as bears tracking the red wave of spawning salmon. This was a novel finding about Kodiak bears with big implications for bear-salmon management. But in 2014, a completely unexpected event occurred in the bears' use of food resources. Bears largely abandoned salmon streams in July and August when salmon were very abundant for an early and copious crop of red elderberries, suggesting a preference for berries over salmon. Will postulates the bears exploit elderberry patches to maximize weight gain.

Will is back at the Refuge this summer for another field season. You can learn more about Will's research and the iconic bears of Kodiak Island at http://www.fws.gov/FieldNotes/regmap.cfm?arskey=35482 and a video of Will presenting his research at https://www.youtube.co/watch?v=w9CboTwjPts. i

Reggie Heiser is the newest member of the maintenance team at the Biological Station. He graduated from Big Sky High School in Missoula, MT and then worked over 20 years for Les Schwab Tire Center in Missoula and Polson.

At the Polson Les Schwab, Reggie met the Station's property and facilities manager Mark Potter, who told Reggie all about the Station. Reggie thought it sounded like a dream job. As the years went by, every time Reggie saw Mark he jokingly asked him, "When are you going to retire, because I'm going to take your job." Mark went into Les Schwab one day and told Reggie that he had indeed retired—next day, Reggie put in his application.

As it turned out, Mark's job went to long-time Station employee Eric Anderson, but Reggie still got his dream job when he started last September as the Maintenance Tech. Reggie is currently working towards a 2C wastewater treatment plant operator certification and has capably jumped into every new assignment at the Bio Station.

Reggie married his high school sweetheart Kelly and they have two daughters Kyla and Miranda who are very active in sports. Due to his new work schedule, Reggie now has more time to spend with family on adventures like camping, hunting, fishing, flying, and everything outdoors. He also has more time for the Polson Volunteer Fire Department where he has volunteered for 3 years. i

Summer Academic Program 2015

Summer courses are in session at the Station June 15 to August 7. At the end of the first week, we asked student Emily Drake if she would recommend the program to anyone. **Emily replied, "Not just anyone, I'd recommend it to everyone! I love it here."**

Thank You To Our Generous Contributors!

December 15, 2013 to May 31, 2015

We are honored tremendously by our contributors—named or anonymous—and we are energized by the help received from many citizen volunteers(*). We wholeheartedly appreciate the generosity and interest you have in the mission of the Flathead Lake Biological Station and the work we do. Thank you from all of us at the Biological Station!

Ellen Achenbaugh*
Jerry Agen
Rosanna Akland
Jefferson & Loretta Amacker
Larry & Marguerite Anderson
Lysbeth Warren Anderson
Wayne Anderson*
Lynn Antill
Richard & Anna Armstrong
Sean Averill
Jack & Audra Baber
Ronald & Denise Baker
Daniel Bangeman
Thomas & Louise Bannigan
Thomas & Anne Bansak
Thomas & Gail Bansak
Rob & Patti Jo Barber
Thomas & Gail Barranger
Steve & Betty Bauer
Annie Beck & Ed Anderson
Monte & Catherine Beck
William Beck Jr
Henry & Irmgard Becker
Boyd & Nancy Behnke
Ken Beiser
Peter & Louise Beiser
William Belknap
David & Elaine Bennett
Kathryn Berg
Jon & Valarie Betz
Harriet Frances Beyer
Erika Binger
BJH Consultants
Allen & Jill Blackford
Diana Blankenship
Charles & Leann Blem
Carroll Blend
Mark & Martha Bond
Nancy Booth
Steve Boyce
Thomas & Sue Bradley
Sally & Paul Bradshaw
Mark Bretz
Lou & Mildred Bretzke
Ted & Stephanie Brockett
Albert & Louise Brown
Claudia Brown & Terry Gruber
Ralph & Patricia Brown
Hayes & Patsy Bryan
Nancy M. Burke
Donald & Jolynne Burks
Donald Busha
Cathleen Caballero
Drew Cable
Darrell Cain
Barbara Callaghan
Dennis & Susan Campbell
Dennis O'Donnell & MaryEllen Campbell
James Caras
Pat & Jennie Carroll
Richard Casey
Stephanie Christensen
Cal & Marva Christian
Tip & Diane Clark
Robert Clithero
John & Anne Collins
Community Foundation for a Better Bigfork
Mark & Nancy Jo Connell
Edwin Cook
David & Jody Cooley
Mike Cooperman & Anne Archer
Kim Corette
Stewart Corn
Steve & Jennifer Corning
Frances Covington
Tom & Caryl Cox
Jeanne Craft
Gayle Crane*
Terry & Joan Cummings
William & Charlene Dale
Patricia Darling
Carla Daum
Ian & Nancy Davidson
Margaret Davis & Bruce Ennis
Robert & Jean Davis
Paul Dearman
Tami & Mike DeGrosky
Michael & Charlotte Delaney
Virgil & Pat Deppmeier
Tom Deveny
Ken & Karen Dial
Gary Dietrich
Leslie Distad
Kelly Dixon
Lee Dixon
Andrea Dockstader
Michael & Jordonna Dores
Rita Dorn
Tom & Cindy Downing
Francesca Droll
Drollinger Family Charitable Foundation
Kathleen Sheehan Dugan
Patrick & Marci Gardner Dunne
Richard & Cynthia Dunshee
Joanne & Hayden Eaves*
Sarah Eddy
Craig & Sharla Ekegren
Arthur Engel
Alice & Gary Erb*
Pat & Jo Ellen Estenson
Judy & David Feffer
Thomas & Mary Fitzsimon
Flathead Lake Land & Home
Flathead Lake Brewing Co.
Edgar & Rita Flink
Flathead Lake Protection Association
Howard & Frances Ruby
David & Teresa Francis
Bill & Carolyn Franke
Clifford & Sally Frey
Ken & Molly Galewyrick
Scott & Gail Galloway
David & Sheila Gardner
Sam Gary
Paul & Lisa Gilbertson
Dale Gillespie
Ed & Nancy Gilliland
Stuart Goldberg
Linda & James Goodrich
Nancy & Jonathan
Richard Gordon
Jens & Jacqueline Gran
Benjamin Graybill
David & Patricia Green
Margaret Green
Sharon Gregg
William & Jeannette Gregg
James & Carol Griffith
Roger Grimes
William & Jan Gromko
William Grunloh
Jon W Haines
Charlie & Myrna Hall
Dorothy Hall
Steven & May Halsey
Roy & Mildred Hamblen
Richard & Vicki Hammer
John Hammett
Barbara Hammons*
Donald & Joan Hanley
Jack & Suzi Hanna
Barry Hansen
Susan Hanson
Johanna & Robert Hanson Jr.
Gay Anne Hainline & Sherry Hardenburgh
Shirley Harrison
Richard & Pauline Hartman
W. Harty
Catherine Haug
Norma & James Hawbaker
Gary Hawk & Joyce Hocker
Merrill Hawley
Gretchen & Edward Heffernan
Klaus & Joaquenia Heinrich
Gilbert & Monica Herrlin
Robert & Judith Hertler
Gregory & Kate Hertz
Paul & Susan Hinman
Ronald & Karen Hoff
Scott & Jody Hollenbeck
James & Wanda Hollensteiner
Tom Howard
Mike Howe
Larry & Kitt Huggins
Eric & Janice Hurst
Linda & David Indrehus
Phil Jackson
Curt, Lanni & Hailey Jacobson
Jarecki Charitable Foundation
A. Felton Jenkins
Daniel & Linda Jenkins
Paul & Ann Jeremiassen
Cameron & Gerri Jewell
Dan Johns
Terry Pearson & Ralph Johns
Ann Mary & Marise Johnson
Alan R. Johnson
Corinne Johnson
Robert Johnsrud & Julie Ellison
Mary Frances & Michael Jones
Paul & Helen Jones
Samuel & Patricia Jones
Beth Judy
Judy Family Foundation
Mike Kadas
Lynn & Beth Kaeding
Joseph Kasperick
James & Wendy Kautz
Wynn & Ginnette Kearney Foundation
Kitty & Denny Kellogg
Martha & Timothy Kelly
Beverly King
George & Wendy Kingston
Lamont Kinkade
Terry & Christie Kinnamon
James R & Sharon L Kitchell
Charles & Marcia Knell
Kathy Knudsen
Ronald & Barbara Kohler*
Linda Kosvic
Jim Kouf, Jr.
Larry & Marian Krummel
Frank & Sandy Kuntz
Tom & Kathleen Kurdy
James Anderson & Julie Kuykendall
Don & Shelly Laine
Craig & Ellen Langel
Gayle Langford
Donald & Jette Laws
Martin Leibenguth
Matthew Levitan
John & Mary Lithgow
Todd Little & Patricia Hawley
Dan & Megan Loftin
Victor & Marlette Louisin
Scott & Sonia Lovett
Charles & Linda MacDonald
Gavin MacPhail
John & Catherine Malison
John & Dolores Malletta
Jim Manley
Don Mann, Mann Mortgage LLC
Nancy & Chuck Manning
Ted & Charlott Mapes
Mary Marshall
James Masek & Mary Peele-Masek
Sherrilyn Mason
Marshall & Karen Mathison
Barbara & Thomas Maxwell
Robert & Marcella McCarthy
Riley & Patricia McClelland
Greg & Susan McCormick*
Robert & Margie McDonald
Mike & Mary McDonough
McGiffert Family
Thomas & Patricia McGrath
Jane & John McKeag
Scott & Terry McKenzie
Michael & Diane McLean
Jayne Flynn McManus
Jerry & Rhona Meislik
Darrell Merrill
Buz & Carole Meyer
Nels Mitchell & Mary Kimmel
Randy & Jim Mohn
Robert & Betty Moore
Pat & Deb Morell
Denise Morigeau
Duane Muhleman
Roger & Nancy Munro
Calvin & Donna Murphy
Steven & Jean Musser
Paul Naour & Ann Hesselink
Marvin & C.A. Narbaitz
Gail Nevin Physical Therapy PC
Jeremy & Deborah Newell
Alan & Nancy Nicholson
Carol & John Noonan
Ken Nordberg, VIP Properties
Margarent Notley
North Flathead Yacht Club
Bjarne & Stella Nylund
David & Eileen Oatley
Roy O'Connor
Debra Ofstad
Mike & Sherry O'Hearn
Bernard L & Joyce Olson
Dan & Jeanne Olson
Stephen & Elaine Olson
Ed & Virginia Onstad
Thomas Osborne
Dave & Nona Overcast
James Paisley
Edison Palacios
Karen & Charles Pannage Jr.
Raymond & Marilyn Parker
Patti & Joe Pastor
Don & Mary Patterson
Eric & Kelly Patterson
Don & Mary Ellen Patton
Ron Paul
Terry Payne
Sara Peck
Jeff & Trisha Peters
Robert & Zina Peterson
Betty Pfeifer
Garry & Christine Pitts
Mark Potter & Robin Steinkraus
Claudia & Allen Potts

Don & Patsy Procunier
Gary & Fran Purdy
Elsa Putzier
John & Camille Rainiero
Paul Rana
Byron & Lois Randall
Jane Ratzlaff, Ratzlaff Consulting
Frank Raucci
Bryant & Nonajean Reber
Sarah Reber & Ben Denckla
Charles & Maureen Redfield
Elizabeth & William Reid
Sam & Bev Reynolds
Tom Richardson
Judy Rigler
Ron & Marilyn Roberts
Allen W. Rodgers
Jim Rogers
Jeff & Mary Roper
Erin & Adam Ross
Lloyd & Bonnie Ross
Rossbach Family Foundation
Steve & Arla Rosso*
James P Roth
Robert Rousselle
Larry & Jo Rowland
Donna & Paul Rowold
Fritz & Amy Royer
Lynette & Sidney Rundell
David Sample
Sauers Properties
Richard & Joan Schleicher
William & Marta Schmale
Marty & Christine Schnell
Cynthia & Tobey Schule
Charlotte Caldwell & Jeffrey Schutz
Jeffrey Schutz, Shilo Partners
Brian & Nancy Schweitzer
Courtney Scott
Homer & Mildred Scott Family Foundation
James & Christine Scott Family Foundation
Jim & Chris Scott
Mick & Marie Seidl
Catriona Shafer
Mikel Shakarjian
Guy & Teri Sharp
James & Janna Shennan
Charles Siderius
Brian & Karen Sippy
Slainte LLC
Everit & Nikki Sliter
Marriott & John Smart
Stanley Smart
Margery Smith
Paula Smith
Ric & Sarah Smith & Century 21
Janice Smith-Kasson
Merlyn & Marie Snavely
James & Ida Snyder
Mickey & Jeff Sogard
Barbara Sokoloski
Dick & Jane Solberg
Nancy & Roy Souder
Craig & Suzannah Spencer
Sara & Joseph Spero
Jody Zadra & Wesley Sprunk
Donald Stein
H. Howard Stephenson
Lillian Stephenson
Len & Christina Stigliano
Joseph & Ellen Stimpson
Jack Stivers
Laurie & Ralph Stone
Western Stone LLC
James & Phyllis Strosahl
Marty & Julia Sunde
Joseph & Annabel Super
Ronald & Wendy Susott
Dean & Barbara Swank
Linda Tabor
Penny Deleray & Eugene Taylor
John & Michele Tenerowicz
Giles Thelen
Charles Thomas
Thomas Thompson
Joan & Dale Thompson
Sara Tiede
Nancy Tiensvold
Kenneth & Deloris (Dee) Tintinger
Gary & Arlyss Toldness
Michael Toth
Treacy Foundation
Mary Ellen & John Turmell
Sidney & Vicki Turnquist
Jeffrey & Susan Tuttle
Daniel & Jo Tuxbury
Curtis & Paula Ullman
Jan & Henry Valentino
Victor & Christine Vance
Donald & Mary Vanlandingham
Kathryn Veazey
Joel & Barbara Vignere
Peter & Kristen Von Doersten
Camden & Ellen Wall
David & Joann Wallenburn
Jack & Linda Walrath
James & Janice Ward
Carol Bibler & Jim Watson
Paul Watson
Stewart & Margaret Weis
Bert & Linda Wells
Thomas Wenke
Timothy & Jane Whaling
Jerry & Donna Whealon
Eric Whetstone
Richard & Nancy Whitaker
Stewart & Patricia White
Jack Whiting
Gary & Teressa Whitney
Nina & Michael Wickersham
Russ & Barbara Wistrand
Robert Wissmar
Gerald & Susan Woodahl
Ann & Ray Wooldridge
Jennifer Lenz & Randal Wright
Michael & Patricia Ann Zabaro
William Zelezny
Shali Zhang

Matching Gift Organizations

AWS Truepower
Chevron Humankind
H.J. Heinz Company Foundation
H&R Block Foundation
William and Flora Hewlett Foundation
Boeing Company
Ingredion
Minnesota Mining Manufacturing Company
Williams Companies Incorporated

Tribute Gifts

Contributions were made to honor the following individuals.

In Honor of Tom Bansak
Dorrance Family Foundation

In Honor of Mary Barnhart
Richard & Marcella Barnhart

In Honor of Mary & John Blair
Phillip & Sue Brown

In Honor of Mary Bettina Burke
R. F. Burke

In Honor of Nancy M. Burke
Burke Family Foundation

In Honor of Charles W. Collins
Mark & Kat Douma

In Honor of Faye M. Couey
Lynnetta Couey

In Honor of John V. Crues Jr
Deborah Lowery

In Honor of Mary Kilts
Carol Cartwright

In Honor of Benjamin A. Foote
Anita Foote

In Honor of Tecky Frankovich
Carole Brophy

In Honor of Walden Jensen
H D & Doris Hanson

In Honor of Jim Kallestad
Connie Kenney

In Honor of SL & Elizabeth Kleve
B Larene Kleve

In Honor of Hedy Kruckeberg
Kurt & Laurie Siedentopf

In Honor of Velora LaMunyon
Roselyn & Raymond Albers
Lois Anderson
Rose Angel
Thomas & Anne Bansak
Chris & Genine Berard
Jeanne Cloud & Donavon Pautzke
Eagle Lake Elementary
Katherine & Eric Grimsrud
Donald & Susan Jurries
Wynn & Ginnette Kearney Fdn.
Dan & Julie Minnick
Paul & Lesley Monfardini
Shawn O'Neill
Richard & Janet Putnam

In Honor of Becky Mattson
Richard & Ursula Mattson

In Honor of Byron L. McGuire
Yvonne McGuire

In Honor of LeRoy Stanford & Sharon Lea McNee
Harold McNee Jr.

In Honor of Harry James Morgan
Pat Morgan

In Honor of Art & Ruth Nelson
Daniel & Carole Driscoll

In Honor of Meryl Cook Patterson
James Patterson Jr .

In Honor of Juanita Rousselle
Karen Robinette

In Honor of James Scarcella
Joan Scarcella

In Honor of Anne Ennis Schwarz, UM '66
John J. H. Schwarz

In Honor of Sallie Sheridan-Corette
Sheridan Brothers LTD

In Honor of Theodore (Ted) M. Smith
Robert & Shari Dayton
Roger & Libby Smith

In Honor of Clarence & Alice Soderstrom
Keith & Dana Soderstrom

In Honor of Dick & Jane Solberg, Chris Solberg & family, Jenanne Solberg & family, Sannan Solberg & family
Bill & Tina Corwin

In Honor of Dr. Charles Stark
Lorrie Stark

In Honor of Lena & Edward Thomas
Patricia & Edmund Colby

In Honor of W.L Thompson
Jack & Alice Thompson

In Honor of Ed & Florence Turnbull
Nancy Fryberger

In Honor of Henry & Mary Walker
Bill & Diana Beaulieu

In Honor of Paul T. Williams
Harriet C. Williams

In Honor of Ace Woods
Gail Woods

FLATHEAD LAKE BIOLOGICAL STATION PUBLICATIONS FROM 2014

Al-Chokhachy, R., C. C. Muhlfeld, M. C. Boyer, L. A. Jones, A. Steed, and J. L. Kershner. 2014. Quantifying the Effectiveness of Conservation Measures to Control the Spread of Anthropogenic Hybridization in Stream Salmonids: a Climate Adaptation Case Study. North American Journal of Fisheries Management 34:642–652.

Andrews, K. R., P. A. Hohenlohe, M. R. Miller, B. K. Hand, J. E. Seeb, and G. Luikart. 2014. Trade-offs and utility of alternative RADseq methods: Reply to Puritz et al. Molecular Ecology 23:5943–5946.

Andrews, K. R., and G. Luikart. 2014. Recent novel approaches for population genomics data analysis. Molecular Ecology 23:1661–1667.

Appling, A. P., E. S. Bernhardt, and J. A. Stanford. 2014. Floodplain biogeochemical mosaics: A multidimensional view of alluvial soils. Journal of Geophysical Research: Biogeosciences 119:2013JG002543.

Bean, J. R., A. C. Wilcox, W. W. Woessner, and C. C. Muhlfeld. 2014. Multiscale hydrogeomorphic influences on bull trout (Salvelinus confluentus) spawning habitat. Canadian Journal of Fisheries and Aquatic Sciences 72:514–526.

Benavides, J. A., P. C. Cross, G. Luikart, and S. Creel. 2014. Limitations to estimating bacterial cross-species transmission using genetic and genomic markers: inferences from simulation modeling. Evolutionary Applications 7:774–787.

Cosart, T., A. Beja-Pereira, and G. Luikart. 2014. EXONSAMPLER: a computer program for genome-wide and candidate gene exon sampling for targeted next-generation sequencing. Molecular Ecology Resources 14:1296–1301.

Griffiths, J. R., D. E. Schindler, J. B. Armstrong, M. D. Scheuerell, D. C. Whited, R. A. Clark, R. Hilborn, C. A. Holt, S. T. Lindley, J. A. Stanford, and E. C. Volk. 2014. Performance of salmon fishery portfolios across western North America. Journal of Applied Ecology 51 1554–1563.

Guan, K., E. F. Wood, D. Medvigy, J. Kimball, M. Pan, K. K. Caylor, J. Sheffield, X. Xu, and M. O. Jones. 2014. Terrestrial hydrological controls on land surface phenology of African savannas and woodlands. Journal of Geophysical Research: Biogeosciences 119:1652–1669.

Hamann, E. J., B. P. Kennedy, D. Whited, and J. Stanford. 2014. Spatial variability in spawning habitat selection by chinook salmon (*Oncorhychus tshawytscha*) in wilderness river. River Research and Applications 30:1099–1109.

Hand, B., S. Cushman, E. Landguth, and J. Lucotch. 2014. Assessing multi-taxa sensitivity to the human footprint, habitat fragmentation and loss by exploring alternative scenarios of dispersal ability and population size: a simulation approach. Biodiversity and Conservation 23:2761–2779.

Helton, A. M., G. C. Poole, R. A. Payn, C. Izurieta, and J. A. Stanford. 2014 (available online January 2012). Relative influences of the river channel, floodplain surface, and alluvial aquifer on simulated hydrologic residence time in a montane river floodplain. Geomorphology 205:17–26.

Jones, L. A., C. C. Muhlfeld, L. A. Marshall, B. L. McGlynn, and J. L. Kershner. 2014. Estimating thermal regimes of bull trout and assessing the potential effects of climate warming on critical habitats. River Research and Applications 30:204–216.

Kang, S., S. W. Running, J. S. Kimball, D. B. Fagre, A. Michaelis, D. L. Peterson, J. E. Halofsky, and S. Hong. 2014. Effects of spatial and temporal climatic variability on terrestrial carbon and water fluxes in the Pacific Northwest, USA. Environmental Modelling & Software 51:228–239.

Kardos, M., F. W. Allendorf, and G. Luikart. 2014. Evaluating the role of inbreeding depression in heterozygosity-fitness correlations: how useful are tests for identity disequilibrium? Molecular Ecology Resources 14:519–530.

Kim, Y., J. S. Kimball, K. Didan, and G. M. Henebry. 2014. Response of vegetation growth and productivity to spring climate indicators in the conterminous United States derived from satellite remote sensing data fusion. Agricultural and Forest Meteorology 194:132–143.

Kim, Y., J. S. Kimball, K. Zhang, K. Didan, I. Velicogna, and K. C. McDonald. 2014. Attribution of divergent northern vegetation growth responses to lengthening non-frozen seasons using satellite optical-NIR and microwave remote sensing. International Journal of Remote Sensing 35:3700–3721.

Kirillin, G., M. S. Lorang, T. C. Lippmann, C. C. Gotschalk, and S. Schimmelpfennig. 2014. Surface seiches in Flathead Lake. Hydrology and Earth System Sciences 11:13541–13570.

Landguth, E. L., C. C. Muhlfeld, R. S. Waples, L. Jones, W. H. Lowe, D. Whited, J. Lucotch, H. Neville, and G. Luikart. 2014. Combining demographic and genetic factors to assess population vulnerability in stream species. Ecological Applications 24:1505–1524.

Lorang, M. S., and D. Tonolla. 2014. Combining active and passive hydroacoustic techniques during flood events for rapid spatial mapping of bedload transport patterns in gravel-bed rivers. Fundamental and Applied Limnology 184:231246.

Madani, N., J. S. Kimball, D. L. R. Affleck, J. Kattge, J. Graham, P. M. van Bodegom, P. B. Reich, and S. W. Running. 2014. Improving ecosystem productivity modeling through spatially explicit estimation of optimal light use efficiency. Journal of Geophysical Research: Biogeosciences 119:1755–1769.

Malison, R. L., M. S. Lorang, D. C. Whited, and J. A. Stanford. 2014. Beavers (*Castor canadensis*) influence habitat for juvenile salmon in a large Alaskan river floodplain. Freshwater Biology 59:1229–1246.

McPhee, M. V., D. C. Whited, K. V. Kuzishchin, and J. A. Stanford. 2014. The effects of riverine physical complexity on anadromy and genetic diversity in steelhead or rainbow trout *Oncorhynchus mykiss* around the Pacific Rim. Journal of Fish Biology 85:132–150.

Mladenova, I. E., T. J. Jackson, E. Njoku, R. Bindlish, S. Chan, M. H. Cosh, T. R. H. Holmes, R. A. M. de Jeu, L. Jones, J. Kimball, S. Paloscia, and E. Santi. 2014. Remote monitoring of soil moisture using passive microwave-based techniques — Theoretical basis and overview of selected algorithms for AMSR-E. Remote Sensing of Environment 144:197–213.

Mouw, J. E. B., T. H. Tappenbeck, and J. A. Stanford. 2014. Spawning tactics of summer chum salmon *Oncorhynchus keta* in relation to channel complexity and hyporheic exchange. Environmental Biology of Fishes 97:1095–1107.

Muhlfeld, C. C., R. P. Kovach, L. A. Jones, R. Al-Chokhachy, M. C. Boyer, R. F. Leary, W. H. Lowe, G. Luikart, and F. W. Allendorf. 2014. Invasive hybridization in a threatened species is accelerated by climate change. Nature Climate Change 4:620–624.

Nichols, C., and M. Lorang. 2014. Sound of Rivers: Stone Drum, Translating limnology into multimedia. *in* Proceedings of Korean Electro-Acoustic Music Society's 2014 Annual Conference (KEAMSAC2014), Seoul Korea, 8–9 October 2014.

Nichols, C., M. Lorang, M. Gibbons, N. B. Browning, and A. Bushnell. 2014. Sound of Rivers: Stone Drum: a multimedia collaboration, with sonified data, computer-processed narration, and electric violin at https://ccrma.stanford.edu/~cnichols/pdf/NicholsRiversICMC2014.pdf.

Parker, S. R., M. N. Darvis, S. R. Poulson, C. H. Gammons, and J. A. Stanford. 2014. Dissolved oxygen and dissolved inorganic carbon stable isotope composition and concentration fluxes across several shallow floodplain aquifers and in a diffusion experiment. Biogeochemistry 117:539–552.

Podest, E., K. C. McDonald, and J. S. Kimball. 2014. Multisensor microwave sensitivity to freeze/thaw dynamics across a complex boreal landscape. Geoscience and Remote Sensing, IEEE Transactions on 52:6818–6828.

Price, M. H. H., A. G. J. Rosenberger, G. G. Taylor, and J. A. Stanford. 2014. Comment: Population structure and run timing of sockeye salmon in the Skeena River, British Columbia. North American Journal of Fisheries Management 34:1167–1170.

(Continued from page 6)

Roffler, G., S. Talbot, G. Luikart, G. Sage, K. Pilgrim, L. Adams, and M. Schwartz. 2014. Lack of sex-biased dispersal promotes fine-scale genetic structure in alpine ungulates. Conservation Genetics 15:837–851.

Valett, H. M., F. R. Hauer, and J. A. Stanford. 2014. Landscape influences on ecosystem function: Local and routing control of oxygen dynamics in a floodplain aquifer. Ecosystems 17:195–211.

Waples, R. S., T. Antao, and G. Luikart. 2014. Effects of overlapping generations on linkage disequilibrium estimates of effective population size. Genetics 197:769–780.

Watts, J. D., J. S. Kimball, A. Bartsch, and K. C. McDonald. 2014. Surface water inundation in the boreal-Arctic: potential impacts on regional methane emissions. Environmental Research Letters 9:075001.

Watts, J. D., J. S. Kimball, F. J. W. Parmentier, T. Sachs, J. Rinne, D. Zona, W. Oechel, T. Tagesson, M. Jackowicz-Korczyński, and M. Aurela. 2014. A satellite data driven biophysical modeling approach for estimating northern peatland and tundra CO_2 and CH_4 fluxes. Biogeosciences 11:1961–1980.

Yi, Y., J. S. Kimball, and R. H. Reichle. 2014. Spring hydrology determines summer net carbon uptake in northern ecosystems. Environmental Research Letters 9:064003. i

Summary of Research Projects – 2014

Project Title	Project Director	Sponsoring Agency
DNA Markers for Sex ID-Bull Trout	Luikart	Avista Corporation
Inundated Wetlands Earth System Data Record	Kimball	California Institute of Technology
SMAP Level 4 Carbon Data Product Algorithm	Kimball	California Institute of Technology
Viral Pathogens via Farmed Salmon	Luikart	Gordon And Betty Moore Foundation
Otter Genetics Project	Luikart	MPG Ranch
DNA Markers to Assess Bull Trout	Luikart	MT Fish Wildlife and Parks
Genetic Evaluation of Lake Trout	Luikart	MT Fish Wildlife and Parks
Genotyping Westslope Cutthroat	Luikart	MT Fish Wildlife and Parks
Changes in Ecosystem CO_2 Exchange	Kimball	NASA Goddard Space Flight Center
SMAP Carbon Cycle Science	Kimball	NASA Goddard Space Flight Center
Assessment Global Freeze Thaw	Kimball	NASA Stennis Space Center
Carbon Cycle Science Contributions	Kimball	NASA Stennis Space Center
Continuity of Freeze/Thaw ESDR	Kimball	NASA Stennis Space Center
Contrasts in CO_2 and CH_4	Kimball	NASA Stennis Space Center
Climate Change Pacific Rim Rivers	Luikart	NASA Stennis Space Center
NSF NEON Yellowstone	Crabtree	National Science Foundation
Brucella Transmission in Yellowstone	Luikart	National Science Foundation
Mechanisms Influencing Spread of Hybridization	Luikart	National Science Foundation
Selection Across Spatial Scales and Environ. Gradients	Luikart	National Science Foundation
Completion of Multispectral Imagery	Hauer	New Mexico Environ. Dept. Surface Water Qual. Bur.
Northshore Erosion Control (2)	Lorang	PPL Montana LLC
Shoreline Restoration Projects (3)	Lorang	Private Citizens
Accuracy Assessment Inundated Wetlands Earth Systems	Kimball	Research Foundation, City University of New York
Riverscape Analysis and Mapping Nushagak River	Whited	The Nature Conservancy
Monitoring of Flathead and Whitefish lakes	Ellis	UM and Private Contributions
Linking Salmon Portfolios	Stanford	University of Washington
Early Detection of Mussels	Luikart	USDA Forest Service Flathead National Forest
Genetic Analysis of Cutthroat Trout	Luikart	USDA Forest Service Flathead National Forest
Genetic Rescue Westslope Cutthroat Trout	Luikart	USDA Forest Service Flathead National Forest
Water Quality Monitoring Near Hungry Horse Dam	Craft	USDI Bureau of Reclamation
South Fork Water Quality Monitoring	Ellis	USDI Bureau of Reclamation
Effects of Climate Change on Aquatic Ecosystems	Hauer	USDI Fish Wildlife Service
Predicting Climate Change Impacts	Luikart	USDI Geological Survey
SNP Genotyping for Lake Trout	Luikart	USDI Geological Survey
Enhance Lake Trout Suppression Yellowstone Lake	Luikart	USDI National Park Service
Transboundary Flathead River	Sexton	Wilburforce Foundation
Transboundary Science Coordinator	Sexton	Wildsight

Flathead Lake Biological Station
University of Montana
32125 Bio Station Lane
Polson, MT 59860-6815 USA
flbs@flbs.umt.edu
http://flbs.umt.edu/
http://flbs.umt.edu/webcams
Phone (406) 982-3301
Fax (406) 982-3201

The Flathead Lake Biological Station is located 17.5 miles north of Polson or 14 miles south of Bigfork. Visitors are welcome year round Monday–Friday to take a self-guided walking tour. For more information, send an email to flbs@flbs.umt.edu, call 406-982-3301 or see the FLBS website at http://flbs.umt.edu/.

VOLUNTEERS *ENGAGE* ON FLBS PROJECTS*!*

Volunteer Ellen Achenbaugh (Polson and the Montecahto Club) assisted for five days, Gary and Alice Erb (Hellroaring Bay and the Montecahto Club) and Ron and Barb Kohler (East Bay) stopped in for a day, and then Gary returned two more days—all were working with Tom Bansak, FLBS Research Scientist/Development Coordinator on a large mailing project. Barbara Hammons (Yellow Bay) also took 500 letters and got them in the mail. Gayle Crane (Gravel Bay) worked on the mailing and returned to help with the 2014 Open House. Volunteers make it possible for FLBS personnel to spend more time informing area citizens and stakeholders about the lake and FLBS research.

Steve Rosso (Lakeside) volunteered to help take water quality samples in Dayton, and Greg McCormick (Flathead Lakers President) participated in buoy retrieval and lake monitoring on the big lake. Wayne Anderson (Rollins) contacted us about doing something special in memory of his wonderful wife Velora LaMunyon. He requested memorial donations be made to the Station and thoughtfully provided his west shore camera feed to link to the Bio Station webcam page. What better way to honor and remember Velora by giving so many an Internet window to gaze upon beautiful Flathead Lake. i

FLBS 2015 Open House August 5, 1 to 5 PM

The Flathead Lake Biological Station's Annual Open House provides an opportunity for the interested public to learn more about the ecology of Flathead Lake and its watershed, as well as FLBS and its research around the globe.

Activities this year will include: tours of FLBS facilities, demo boat trips on our newly refurbished 30' research vessel, the *Jessie B* (below), exhibits of recent Flathead research and presentations by FLBS research scientists. This event is open to all and there is no admission fee. For more information, email Tom Bansak at tom.bansak@umontana.edu or call 406-982-3301 x229. i

The Flathead Lake Journal is a publication of the Flathead Lake Biological Station (FLBS). This issue was coedited by Marie Kohler, Sue Gillespie, Jack Stanford and Tom Bansak.