the Shellcracker

FLORIDA CHAPTER OF THE AMERICAN FISHERIES SOCIETY

http://www.sdafs.org/flafs

January, 2013

President's Message:

Happy New Year, Florida Chapter!

At last year's business meeting, we discussed the possibility of hosting a national American Fisheries Society meeting. According to the AFS Procedures Manual (http://fisheries.org/docs/about_procedure.pdf), the parent society solicits bids from chapters and state agencies for its annual meetings more than four years prior to the actual event. Successful bids usually have the strong support of a local AFS Chapter and/or a regionally based state or federal agency willing to help sponsor the event by providing volunteer employees and services to offset some of the costs associated with organizing such a large conference. The most successful bids to host AFS annual meetings have been those demonstrating a wide variety of competitive airfares to the host city, reasonable hotel rates to accommodate a large block of rooms, centralized lodging and conference facilities, free use of convention facilities, availability of discounted student room rates, and a host of social activities and attractions for members and guests.

Over the last several months, the executive committee has visited Orlando, Jacksonville, Tampa, and Ft. Lauderdale to scout convention facilities for a national meeting bid. At our chapter business meeting in February, we will be briefing the membership on and recommending one of these potential host cities. If the membership decides to support a national bid, we will need to start putting together a proposal to present at the 2013 National Meeting in Little Rock, Arkansas. Hosting a national meeting is a big commitment, and to be successful, the chapter will need several members to step up into leadership roles, as well as participate on committees. Past successful bids are associated with a large number of AFS members in the host city or its surrounds - individuals who are willing to work on Local Arrangements-related activities – this means US!! Please take some time before the annual chapter meeting to evaluate your availability to help in this exciting endeavor. Before leaving the Ocala 4-H camp, it would instrumental to have committee and subcommittee chair volunteers so that we can start the planning process. Listed below are the committees that will need to be filled. Specific duties are described in the procedure manual (link above), so take a look and see which areas interest you. Sign-up sheets will be available at the Florida chapter meeting!

Local Arrangements

The Local Arrangements Committee (comprised of subcommittee chairs) will be headed by the General Meeting Chair who must delegate responsibilities early in the game. It is desirable that the General Meeting Chair be headquartered in close enough proximity to the meeting site to permit easy personal contact with hotel and convention facility staff at all times.

Suggested Subcommittees:

Accommodations; Audio Visual Aids; Banquet, Social Activities, and Entertainment; Budget and Finance; Child Care; Communications; Fundraising; Hospitality; Photography; Printing (oversight, most functions performed by AFS staff); Program Committee Rep (Co-Chairs); Publicity and Media Relations; Raffle; Registration (oversight, most functions performed by AFS staff); Signs; Spawning Run; Students; Tours, Transportation, and Information; Trade Show; Welcoming and Protocol.

Kerry Flaherty
President, Florida chapter of AFS

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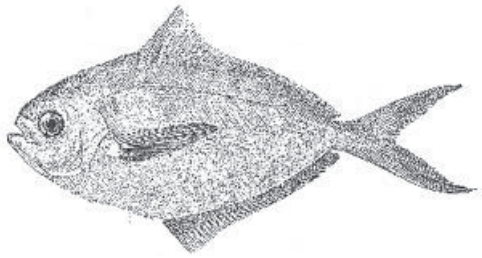


Upcoming Events

33rd Annual Meeting of the Florida Chapter of the American Fisheries Society*, February 19-21, 2013. Altoona, FL. See page 3 for details. Still time to Register.*

2013 Southern Division AFS Spring Meeting *- February 7 -10, 2013 in Nashville, Tennessee. http://www.sdafs.org/meetings/2013/default.htm*

2013 ASLO. American Society of Limnologists and Oceanographers, New Orleans, LA. 17-22 February 2013. http://www.aslo.org/meetings/neworleans2013

2013 NANFA Convention *- Kentucky May 2nd-5th, 2013, Cumberland Falls State Park. http://www.nanfa.org/convention/2013.shtml*

2013. Joint Meeting of the American Society of Ichthyologists and Herpetologists. *Albuquerque, New Mexico, 10-15 July 2013. http://www.asih.org/*

2013 Annual Meeting of the American Fisheries Society. *Little Rock, Arkansas. Sept. 8-12.*

Please help get donations for our February 2013 Student Raffle (See page 7 for more Infor-

Check out our Parent Society's calendar at http://www.fisheries.org/afs/calendar.html for other events not listed here!

Annual Meeting and Symposium Announcement – 2nd Call for Papers
33rd Annual Meeting of the Florida Chapter of the American Fisheries Society

February 19-21, 2013

Ocala 4H-Camp, Altoona, Florida

The 2013 meeting is only a month away, and it's time to submit your abstract, register, and make your plans to attend the meeting! The meeting format will consist of both invited and contributed oral presentations and posters. The symposium on Wednesday will be 'Long-term monitoring: designs, problems, and results.' Long-term monitoring programs take a considerable amount of time, effort, and funding. Two of the most common and important questions about monitoring programs are: Why are they taking place? How are they used? Six monitoring programs in Florida will be highlighted at this year's symposium and will address these questions along with the design, problems, and results of the programs. After the overview of the programs, contributed papers that use long-term monitoring data will be presented. If you have long-term monitoring data that you would like to share, please submit an abstract.
All abstracts are due ***Friday, January 11, 2013***, for full consideration in the symposium or contributed sessions. Please send your abstract (<300 words) and associated information (following the format given below) to **travis.tuten@myfwc.com**; in the subject line of your email, please list the author(s) as they will appear in the program (e.g., SchaubMooreMajikowski.doc). Platform presentations will be 20 minutes (15 minutes for presentation and 5 minutes for questions or discussion). We will have **PowerPoint 2007** loaded on a laptop capable of accepting your presentation on a CD, DVD or flashdrive. All posters will be formally presented on Tuesday evening, February 19, and can be left up for the entire meeting. Posters should be no larger than 150 X 100 cm (60" X 40"), but they can be set up either as portrait or landscape format on an easel.

The 2013 meeting will again be held at the Ocala 4-H Camp, on Sellers Lake in the Ocala National Forest. This venue is located east of Ocala, south of SR 40, just off SR19. Maps and directions will be available in the next issue of the Shellcracker or can be found at 4-H Camp Ocala's website 4-H Camp Ocala. The meeting's schedule will be similar to recent past meetings. We will begin at noon on February 19th. Lunch will be served and then followed by the presentation of contributed papers. The poster session will take place following dinner on Tuesday evening. The 'Long-term monitoring: designs, problems, and results.' symposium will start on Wednesday morning. The business meeting and raffle will follow dinner on Wednesday night. We will hear more contributed papers on Thursday morning, followed by lunch and the presentation of awards immediately following lunch.

For your convenience, we are again planning to have registration available online: 2013 FLAFS Meeting Online Registration. Once you fill out the online form, you can either pay online through PayPal or print the completed form and mail it in with your check, cash, or money order.

If you would rather not use the online form, a hard copy of the registration form as used in previous years can found in this issue of the Shellcracker or on the Chapter's website: Florida Chapter AFS

Please note the savings available if you register on or before January 11, 2013. This helps in many ways: reduces everyone's registration time, gives us a head's up on the count for meals, saves money, gets the correct amount of t-shirts or hats, and you don't miss any talks. Therefore, please **pre-register by completing the registration form** (online or hard copy) **and sending in your deposit** online through PayPal or by mail to the Chapter's Secretary-Treasurer, Cheree Steward (see registration form for Cheree's contact information), **by January 11, 2013**. Lastly, you should plan to bring your own linens or sleeping bag if you are planning to sleep at the camp. Linens will only be available in limited supplies and for a small fee.

Students: Student travel awards will be available for the annual meeting. Master's and doctoral students are also eligible for the Roger Rottmann Memorial Scholarship, for which the recipient(s) will be announced at the annual meeting. More information and the application materials are available at FLAFS Awards and Scholarships.

We're looking forward to returning to the beautiful 4-H camp for our 2013 annual meeting, and hope to see you there!

Sincerely,
Travis Tuten
FL AFS President-Elect

Abstract Format:

Limit abstracts to ≤ 300 words and follow this format (2007 MS WORD is preferred):

Presenter: Williams, Brian; Email: BrianWilliams@FloridaFish.net;
Author(s): Williams, B.[1], K. Rowley[1], and P. George[2].
[1]Affiliation. Address.
[2]Affiliation. Address.

Title: Recommendations for New Limits on Some of Florida's Most Targeted Fish Species

Abstract: <300 words (MS Word will count it for you)

Student Presentation: No or Yes (work reported was completed while a student)

Presentation type: Oral or Poster

Would you like to be considered for the symposium? Yes or No

Are you willing to be a moderator? Yes or No

Are you willing to be a judge? Yes or No If so, oral presentation or poster?

DRAFT PROGRAM SCHEDULE
33rd Annual Meeting of the Florida Chapter American Fisheries Society
February 19-21, 2013
4-H Camp Ocala, Altoona, Florida
Tuesday, February 19
1100-1800 h Registration
1200-1300 h Lunch
1300-1700 h Contributed Papers
1700-1900 h Poster Setup
1800-1900 h Dinner
1900-2000 h Formal Poster Session ….Followed by the ***Bonfire Social***

Wednesday, February 20
0700-0800 h Breakfast
0730-1800 h Registration
0800-1200 h **Symposium:** *Long-term monitoring: designs, problems, and results.*
1200-1300 h Lunch
1300-1700 h **Symposium** (continued), Contributed Papers
1700-1800 h Student Subunit Meeting (all students); Time to relax (all others)
1800-1900 h Dinner
1900-2000 h **Chapter Business Meeting**
Awards presentation: Student Awards – Travel and Roger Rottmann Scholarship &
Professional Awards – Outstanding Achievement and Rich Cailteux
Followed by **THE RAFFLE, AUCTION,** and the ***Bonfire Social***

Thursday, February 21
0700-0800 h Breakfast
0730-0900 h Registration
0800-1200 h Contributed Papers
1200-1300 h Lunch
1300-1310 h **Awards Presentation**: Best Papers/Best Posters; Power Tie and Lampshade Awards

Florida Chapter of the American Fisheries Society
4H Camp Ocala, Florida
Annual Meeting Registration: February 19-21, 2013

First: _____ **Last:** _____ ☐ **Student (please check)**

Affiliation: _____
This address will be used in our mailing list and should be the one where you want to receive materials.

Street Address: _____

City: _____ **State:** _____ **Zip Code:** _____

Work Phone: _____ **Ext** _____ **Email:** _____

T-Shirt Size: (Select One) Small Medium Large X-Large XX-Large XXX-Large

Arrival Time: (Select One) Tue Noon Tue PM Wed AM Wed Noon Wed PM Thur AM

Please check the appropriate boxes below.

PRE-REGISTRATION: registration form postmarked by Friday, January 11, 2013
☐$ 30.00 One-day Registration ☐$ 40.00 Full Registration

LATE-REGISTRATION: registration form postmarked after Friday, January 11, 2013
☐$ 35.00 One-day Registration ☐$ 47.00 Full Registration

Meals and Lodging

Tuesday, February 19, 2013
- ☐ $8 Lunch
- ☐ $14.50 Dinner
- ☐ $27.00 Lodging

Wednesday, February 20, 2013
- ☐ $6.50 Breakfast
- ☐ $8 Lunch
- ☐ $14.50 Dinner
- ☐ $27.00 Lodging

Thursday, February 21, 2013
- ☐ $6.50 Breakfast
- ☐ $8 Lunch

Full Meals and Lodging ☐ **$120.00**
Linens (please bring own, limited supply) ☐ $ 6.00

Florida Chapter dues (calendar year 2013) ☐ **$10.00** ☐ FL Chapter dues paid via AFS annual membership.

Total Amount

Total Enclosed:
(Minimum $10)

Balance Due

Please Make Checks Payable to Florida Chapter, AFS and mail to:

Cheree Steward
FWC
601 W. Woodward Ave.
Eustis, FL 32726

Phone: (352) 357-2398 ext. 244
Fax: (352) 357-2941
Email: cheree.steward@myfwc.com

*Checks not payable to 'Florida Chapter AFS' will be returned to sender.
Registration Forms may be sent via fax (attention: Cheree) or via email: (subject: 2013 AFS FL).
A minimum amount of $10 must be mailed to validate your registration.

note: This is a cafeteria-style service and food must be ordered a week in advance.
Since meals are pre-paid, **please** submit your registration form as soon as possible.
Registrations will still be accepted at the meeting, but with a late registration fee.
We can only accept **non-FWC VISA** or **MASTERCARD** on the meeting date**.**
Credit card charges are submitted by our parent organization, AFS, after the meeting.
If you would like to pay your meeting fees with a credit card, then please send a $10 check for your deposit.

Reminder for Award Nominations!?!

The Awards Committee is seeking nominations for the Florida Chapter's, Outstanding Achievement and Rich Cailteux Awards. Send nominations to Eric Nagid (eric.nagid@myfwc.com) by January 11, 2013. Applications should be limited to one page, but descriptive enough to convey why the individual is deserving of the award. Nomination letters should outline the accomplishments of the individual that meet the criteria of each award below.

Outstanding Achievement Award

The purpose of the Outstanding Achievement Award is to recognize individuals for singular accomplishments and contributions to fisheries, aquatic sciences, and the Florida Chapter. The award aims to honor individuals for distinct contributions to the fisheries profession and enhancing the visibility of the Chapter. The Outstanding Achievement Award is the highest honor Florida AFS may bestow upon an individual member or collaborating group.

Candidates will be evaluated according to the following criteria:

- Original techniques or research methodology
- Original ideas, viewpoints, or data which contributed to fisheries management or our understanding of aquatic resources
- Important ecological discoveries
- An original fishery research or management program of statewide importance

Activities in public education and outreach that have statewide impacts

Rich Cailteux Award

The purpose of the Rich Cailteux Award is to recognize individuals who have maintained a long-term commitment to research, management, and/or conservation of Florida fisheries and aquatic resources. This award aims to honor individuals for their career contributions to the fisheries profession and enhancing the visibility of the Florida Chapter.

Candidates will be evaluated according to the following criteria:

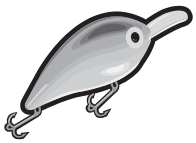
- A minimum of 20 years spent in a fisheries related field in Florida
- Substantial career contributions to Florida aquatic resources and the fisheries profession
- An imaginative and successful program in fisheries and aquatic sciences education

A history of mentoring young fisheries professionals, and involvement and leadership with the Florida Chapter of the American Fisheries Society.

Directions to Ocala 4-H Camp:

The Ocala 4-H Center is located in the Ocala National Forest on Sellers Lake. Directions are provided below for those traveling from different parts of the state. Mileage estimates are to be used for general reference only.

From SW:
Take I-75 N to 44 E, -head towards Leesburg, -turn right onto 441 S, -in Eustis, take exit for 19N (on right), -turn left at light and head north on 19 N for ~19 mi., -turn left onto NFS 535 at the Fire Control Center/Camp Ocala 4-H Center sign. Center will be on the right about 1/2 mi.
From SE:
Take Turnpike N to 429 N towards Apopka, turn left onto 441 N, -once in Eustis, take a right onto 19 N., -go for ~19 mi. and turn left onto NFS 535 at the Fire Control Center/Camp Ocala 4-H Center sign. Center will be on the right about 1/2 mi.
From NW:
Take I-75 S to Ocala, take the exit for 326 E, when 326 ends, turn left onto 40 E, turn right onto 19 S, go for ~4.5 mi. and turn right onto NFS 535 at the Fire Control Center/Camp Ocala 4-H Center sign. Center will be on the right about 1/2 mi.
From NE:
Take 17 S to Palatka, turn right onto 19 S, go for ~42 mi. and turn right onto NFS 535 at the Fire Control Center/Camp Ocala 4-H Center sign. Center will be on the right about 1/2 mi.



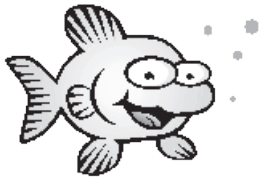
Our 2013 Meeting Student Raffle:

Please help get donations for our February 2013 Student Raffle:

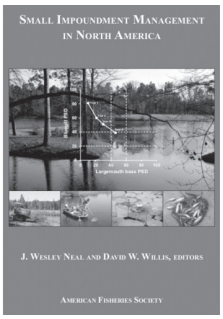
The donations for our February 20 Raffle are coming in rather slowly. We still need volunteers to request donations from just about every area in the state. We all really enjoy the Raffle and what it does for our Students and Chapter, but it takes more than just a few of us to make it happen. **Carla Garreau**, the Student Subunit Vice President from UF, will be up front for the Raffle this year and she is seeking volunteers from each of the Universities involved. Alan Collins is organizing the overall effort to bring in donations and we are especially looking for more volunteers from Pensacola, Tallahassee, Jacksonville, Orlando, Ocala, Fort Myers and Miami/the Keys. If you can spare a little time the next few weeks, please e-mail or call Alan Collins at lac96@bellsouth.net or 850-303-4434 and we will gladly e-mail you a donation-request-letter-template for businesses. It really only takes half a day to make a difference!

We would ALL appreciate it.

'Cause Everybody loves Chum!



New Titles from AFS

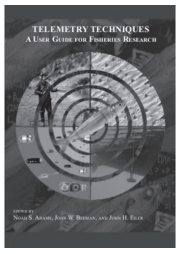


Small Impoundment Management in North

J. Wesley Neal and David W. Willis, eds. 451 pages, index, hardcover
Published by the American Fisheries Society

ISBN: 978-1-934874-34-9

An in-depth overview of biota, habitat, and human management in small water bodies up to 40 ha in surface area. Authors cover the wide geographic diversity of ponds and pond management accross North America. A primary use for this book will be university classes on pond or small impoundment management for advanced undergraduate or graduate students. Practicing fisheries professionals should also find substantial value in the depth of information provided by the book. Finally, private pond owners will find the book to be useful as they seek to learn more about ponds and pond management.



Telemetry Techniques: A User Guide for Fisheries Research

Noah S. Adams, John W. Beeman, and John H. Eiler, eds.
518 pages, index, hardcover
Published by the American Fisheries Society

Telemetry provides a powerful and flexible tool. It is also technologically intensive requiring more specialized knowledge and training than many field techniques. As with other scientific methods, collecting good data is dependent on an understanding of the underlying principles behind the approach, knowing how to use the equipment and techniques properly, and recognizing what to do with the data collected.

This book is a users guide for using telemetry to study aquatic animals, and provides the basic information needed to plan, implement, and conduct a telemetry study under field conditions. Topics include acoustic or radio telemetry study design, tag implantation techniques, radio and acoustic telemetry prin-

Advances in Fish Tagging and Marking Technology

Jeremy McKenzie, Bradford Parsons, Andrew Seitz, R. Keller Kopf, Matthew Mesa, and Quinton Phelps, eds.
560 pages, hardcover, Symposium 76
Published by the American Fisheries Society
Publication date: May 2012

The technologies and analytical procedures available for marking and monitoring fisheries are evolving. This book examines the newest integrated approaches, conventional tagging, acoustic tags and arrays, radio telemetry, chemical and biological markers, and archival and pop-up satellite tags.

Graduate Assistantships (Two) Fisheries and Aquatic Sciences, University of Florida

Position: PhD Graduate Assistantships (2)
Agency/State: University of Florida
Responsibilities: Assistantship (20 hr/wk) is for research on the effects of the BP Deep Water Horizon oil spill on recreational and commercial fisheries in the Gulf of Mexico. Students will be responsible for contributing to field and lab work collecting and processing fish and analyzing growth, and will be expected to develop their PhD projects that complement this central research theme.
Qualifications: M.S. in fisheries, biology, ecology, or related field. A strong work ethic and experience in coastal, offshore, or Great Lakes field work required; strong writing and quantitative skills desired. Must be able to participate on some weekend and week-long field sampling trips.
Salary: $22,000/yr plus tuition waiver and student health benefits for 3 years.
Closing Date: 28 January 2013 (Positions begin in May 2013)
Contact/Email: Send cover letter describing your professional interests and experience, CV, copies of unofficial transcripts, GRE scores, and three references to: Dr. Debra Murie (dmurie@ufl.edu) and Dr. Daryl Parkyn (dparkyn@ufl.edu). For more information, please call Dr. Murie at (352)-273-3601.

Student Sub-Unit News

The Florida Chapter Student Sub-Unit elects new officers each year for President, Vice-President, and Treasurer. So, if you are a student and are planning on attending this year's annual meeting, please consider running for one of these positions.

For questions about their responsibilities please contact Janice Kerns at janice.kerns@ufl.edu

Interested in contributing something to the Shellcracker? Email Daryl Parkyn dparkyn@ufl.edu articles or information that you would like to be included upcoming issues. The deadline for the next issue is March 31st, 2012, so start fishing...

Student Section

Featured Article: Student Research Highlight

Hydrilla impacts on dissolved oxygen and fish habitat quality in two Florida lakes

Erin Bradshaw Settevendemio[1], Micheal S. Allen[1], and Michael D. Netherland[2]
[1] University of Florida, School of Forest Resources and Conservation, Program of Fisheries and Aquatic Sciences, 7922 NW 71st St., Gainesville, FL 32653
[2] US Army Engineer Research and Development Center and UF Center for Aquatic and Invasive Plants. 7922 NW 71st Street Gainesville, FL 32653

Abstract
The fast growth and dense structure of some macrophyte species can alter water chemistry and impact fish habitat quality. Hydrilla, *Hydrilla verticillata* is an invasive aquatic weed which exhibits rapid growth and may contribute to low dissolved oxygen concentrations (hypoxia, DO <2.0 mgL^{-1}) during warm summer months. We evaluated the spatial and temporal dynamics of dissolved oxygen in three habitat types: open water, edge of beds, and the dense hydrilla bed interior, in two Florida lakes. Our results showed that habitat type, month, and depth all significantly influenced dissolved oxygen and up to 100% of the water column was severely hypoxic (DO <1.0 mgL^{-1}) in dense and edge habitat types in late summer in the small lake. However, we found no hypoxia in the large lake. These results suggest that lake morphology and size could influence the impacts of hydrilla on water quality. Additionally, increasing edge habitat may not greatly influence DO concentrations unless substantial open-water area adjacent to dense beds is maintained for adequate water cycling.

Introduction

Submersed macrophytes offer beneficial fish habitat by providing ample food resources and refuge from predators (Crowder and Cooper 1982). However, macrophytes at high densities can alter water chemistry and adversely affect habitat quality (Caraco et al. 2006). Invasive aquatic plants frequently obtain higher biomass and coverage than many native plants due to rapid growth, lack of natural predators, and adaptation ability (Gurevitch et al. 2006). The morphology of macrophyte species, such as branching and leafing, can contribute to low dissolved oxygen (DO) by shading sunlight during the day, respiring at night, and reducing water circulation (Bowes et al. 1979; Caraco et al. 2006).

Hydrilla verticillata (commonly called hydrilla, as well as water thyme or Florida elodea) is an invasive aquatic weed exhibiting dense stemming throughout the water column and produces a thick, branching mat at the surface. Hydrilla supports high abundance of small and young fishes attracted by structural habitat and macro-invertebrate resources (Barnett and Schneider 1974; Tate et al. 2003); however, the inverse relationship between vegetation density and dissolved oxygen (DO) may influence how fish use this habitat (Miranda and Hodges 2000; Burleson et al. 2001). Maximum growth of hydrilla combined with rising water temperatures during summer and nightly respiration can potentially result in hypoxic (DO <2.0 mgL^{-1}) conditions considered unsuitable for fish utilization (Miranda et al. 2000).

Our objectives were to (1) evaluate DO dynamics at temporal and spatial scales across three habitat types (open water, edge of hydrilla beds, and dense hydrilla bed interior) and compare these results between one small and one large Florida lake. This information will help resource managers determine where suitable habitat may be limited and require management actions.

UF Masters of Science Student Erin Bradshaw Settevendemio

Methods

Study Area: Sampling took place on Sandmine Lake (28°91 N, 81°57 W) in Lake County and Lake Tohopekaliga (28°10 N, 81°23 W) in Osceola County, Florida. Sandmine Lake is a 121-hectare man-made lake and former sandmine operation in the Lake Norris Conservation Area, owned by the St. Johns River Water Management District (SJRWMD 2011). Its depth is variable from 2-9 meters. The study area was located in the southern end, adjacent to the deepest portion (mining area) of the lake where consistent open water was found with adjacent dense hydrilla beds. By late summer, the high majority of the lake was covered with *Hydrilla* mats except for the deep mining area.

Lake Tohopekaliga (Toho) is a 9,186-hectare lake in the Kissimmee Chain of Lakes, and a popular sportfishing destination in central Florida (D'Andrea 2010). Its depth ranges from 2-5 meters. The study area was located in Goblet's Cove on the eastern portion of the lake. Lake Toho is heavily managed for its sport fishery, recreational boating, and the endangered snail kite, *Rostrhamus sociabilis*. Both lakes contain fish species common to Florida, including sportfish such as sunfish (*Lepomis spp*., largemouth bass, *Micropterus salmoides*, and crappie, *Pomoxis nigromaculatus*.

Dissolved Oxygen Sampling

We used Yellow Spring Instruments (YSI, Model 556 MPS) handheld multiparameter sondes to evaluate the spatial and temporal fluctuation of dissolved oxygen (mgL^{-1}) from June – October 2012. Sampling was conducted during early morning hours when DO was expected to be lowest due to nightly macrophyte respiration (Hannan and Anderson 1971); specifically, this was from dawn until a maximum of four hours after dawn. We also collected data in the afternoon, from four hours before dusk until a maximum of one-half hour after dusk, for comparison. Twenty-five water quality samples were recorded at random sites within each habitat type (dense, edge, open water) at three defined depths: surface (0.00-0.61 m), mid (0.61-1.21 m), and deep (1.21-1.81 m). Due to hurricane conditions in late October, we were only able to obtain 15 samples from Sandmine Lake early morning sampling, and no data was attainable for afternoon sampling or at Lake Toho.

Each sampling locale was a minimum one boat length from the previous location. Six to seven samples were taken at least one meter apart at each locale and marked with Global Positioning System receivers.

Although the lake bottom was deeper than 1.82 m, the Florida Department of Environmental Protection (FDEP) recommends DO sampling be conducted in the upper half of the water column or upper 2 m where total lake depth exceeds 4 meters. The rationale is that the littoral zone habitat is most often utilized by the fish and invertebrates under consideration, and thus focus should be on this stratum (FDEP 2012).Currently, the minimum dissolved oxygen standard is set at 5.0 mgL^{-1} by the FDEP; however, a statewide review revealed that 52-70% of sampled Florida lakes and rivers fail this criterion (FDEP 2012). The state of Florida has now proposed a new DO criterion based on regional regression analysis of average condition indices and daily average DO saturation to determine minimum DO concentrations for systems experiencing naturally-low DO. This analysis concluded that DO saturation of 38% (3.0 mgL^{-1}) reached during the daily workday period (8:00 – 17:00) is necessary for healthy biological systems in Peninsular Florida (FDEP 2012). With consideration of this report, the typical diel cycle of oxygen output and uptake by plants, and the primary literature on the hypoxia tolerance of fishes, we categorized dissolved oxygen concentrations and hypoxia as "severe" being less than 1.0 mgL^{-1} , "stressful" being DO 1.0-2.0 mgL^{-1} , and "adequate" being over 2.0 mgL^{-1} (Moss and Scott 1961; Miranda et al. 2000).

Vegetation sampling

We also collected hydrilla biomass samples to compare relative vegetation density with dissolved oxygen concentrations. A vertical biomass rake (Johnson and Newman 2011) was used to collect hydrilla samples at four random locations within dense hydrilla beds every month in both lakes. Collected vegetation was placed in a dry oven set at 77-79°C for a minimum of 48 hours, and weighed. Biomass samples were averaged and extrapolated to kgm^{-2} dry weight.

Analysis

Analysis of variance (ANOVA) was used to determine if dissolved oxygen varied by month (4 or 5 months: June – September/October), habitat type (3 types: dense, edge, open water), and depth (3 depths: surface, mid, deep) in full factorial design, separately for each lake, and for afternoon dissolved oxygen means. Factorial design was chosen a priori because we believed that all factors could influence dissolved oxygen simultaneously. Post-hoc analyses were performed for specific comparisons with Tukey's Honestly Significant Difference test. These comparisons were 1) surface versus deep DO within each habitat type in June and September, and 2) surface DO between habitat types in September. Surface level was chosen for between-habitat comparisons because it was consistently the highest DO throughout the water column.

Results

Sandmine Lake

For early morning and afternoon DO means, all main effects (month, habitat type, and depth) and lower-level interactions were highly significant (ANOVA, $p<0.001$). However, the three-way interaction was also highly significant, indicating that all factors in combination have substantial influence over dissolved oxygen, as well as influence over each other, during the summer season (ANOVA, $p<0.001$).

Dissolved oxygen declined with month and depth over the summer season in all habitat types (Figure 1). Surface-level DO was significantly higher than deep for all habitat types in June (Tukey HSD, $p<0.001$), indicating a strong DO gradient. Low dissolved oxygen was first seen in August, with hypoxia extending throughout the entire water column in dense and edge habitat types. Dissolved oxygen declined to severe hypoxia in September with a very weak depth gradient; surface DO was not significantly higher than deep DO in any habitat type (Tukey HSD, $p>0.05$). Between-habitat comparisons showed mean surface DO in edge habitat was not significantly higher than in dense habitat, and although hypoxia in open water was less severe than in dense and edge habitat types, it was not significantly higher (Tukey HSD, $p>0.05$).

Instance of hypoxia declined in the afternoon so that DO reached the FDEP recommended minimum (DO $\geq$ 3.0 mgL^{-1}) in the surface of the water column in all habitat types (Figure 2).

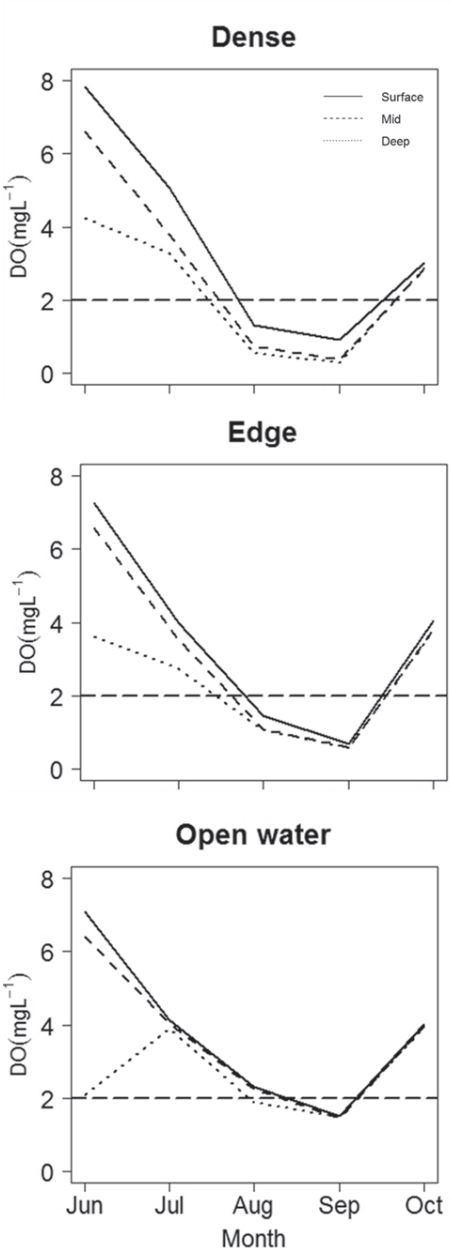


Figure 1. Early morning mean dissolved oxygen concentrations (N=25 for June – September, N=15 for October) for dense, edge, and open water habitat types by month and depth at Sandmine Lake, June – October 2012. Long-dashed line set at 2.0 mgL^{-1} represents the threshold of hypoxia.

Surface DO was significantly higher than deep DO (Tukey HSD, $p<0.001$), indicating the return of a substantial DO gradient in all habitat types. Between-habitat comparisons of surface DO showed edge habitat was not significantly higher than dense habitat (Tukey HSD, $p>0.05$) and not significantly different from open water (Tukey HSD, $p>0.05$). Interestingly, dense habitat surface DO was significantly higher than open water (Tukey HSD, $p<0.001$).

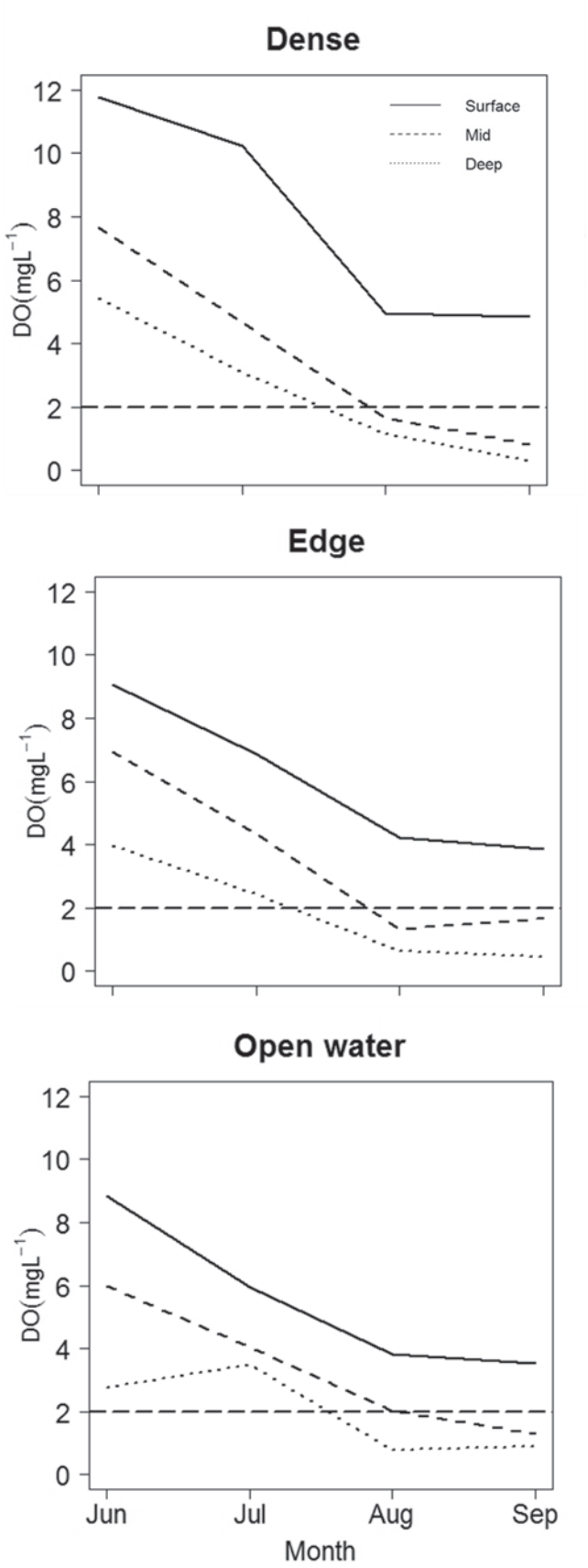


Figure 2. Afternoon mean dissolved oxygen concentrations (N=25) for dense, edge, and open water habitat types by month and depth at Sandmine Lake, June – September 2012. Long-dashed line set at 2.0 mgL^{-1} represents the threshold of hypoxia.

Mid-level DO was consistently hypoxic in all habitat types (though severely in dense habitat) for both times of day; thus, hypoxic conditions were maintained at this stratum from August through September. Instance of hypoxia and severity declined in October.

Lake Tohopekaliga

Dissolved oxygen did not decline to hypoxic concentrations at any time or depth over the summer season in Lake Tohopekaliga (Figure 3). Regardless, the ANOVA model found similar results to that of Sandmine Lake in that all main effects and lower-level interactions were highly significant, as well as the three-way interaction of month, habitat, and depth, suggesting these factors significantly influence each other and dissolved oxygen in this lake (ANOVA, $p<0.001$). There was a strong DO gradient in all habitat types in June (Tukey HSD, $p<0.001$) which became very weak in September (Tukey HSD, $p>0.05$). Although data collection was not possible in October, it is unlikely hypoxia occurred if it was not evident in September when hydrilla growth and day length were at a maximum. Between-habitat comparisons for September in Lake Toho showed mean surface DO did not vary significantly between any habitat types (Tukey HSD, $p>0.05$).

Similarly, ANOVA analysis of afternoon dissolved oxygen showed all main effects, lower-level interactions, and the three-way interaction of month, habitat type, and depth to significantly influence dissolved oxygen (ANOVA, $p<0.001$). While there was a weak DO gradient in September during early morning hours, a strong DO gradient return in the afternoon in vegetated habitat types (Tukey HSD, $p<0.001$), but not in open water (Tukey HSD, $p>0.05$) (Figure 4). Between-habitat comparisons showed that surface DO had a positive relationship from open water into dense hydrilla, with dense habitat was significantly higher than edge or open water (Tukey HSD, $p<0.001$), and edge significantly higher than open water (Tukey HSD, $p<0.001$).

Vegetation Biomass

Hydrilla biomass maintained very high densities throughout summer into October at Sandmine Lake, with the lowest dryweight biomass density close to 1.5 kgm^{-2} or well above (Figure 5).

Relative density of hydrilla was 2-3 times less at Lake Tohopekaliga as compared with Sandmine Lake. Samples were variable with the rake method; however, consistent method of collection allowed us to see a general trend of hydrilla growth and relative density among months and between lakes.

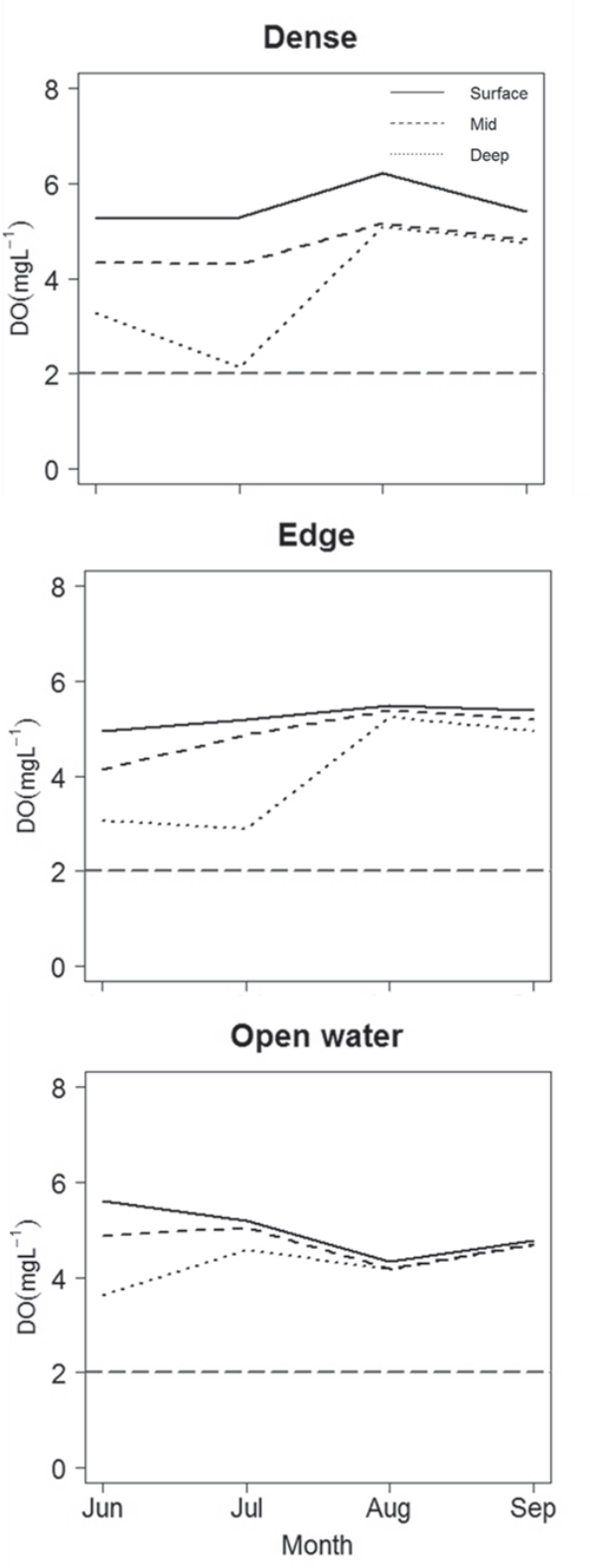


Figure 3. Early morning dissolved oxygen concentrations (N=25) for dense, edge, and open water habitat types by month and depth at Lake Tohopekaliga, June – September .2.

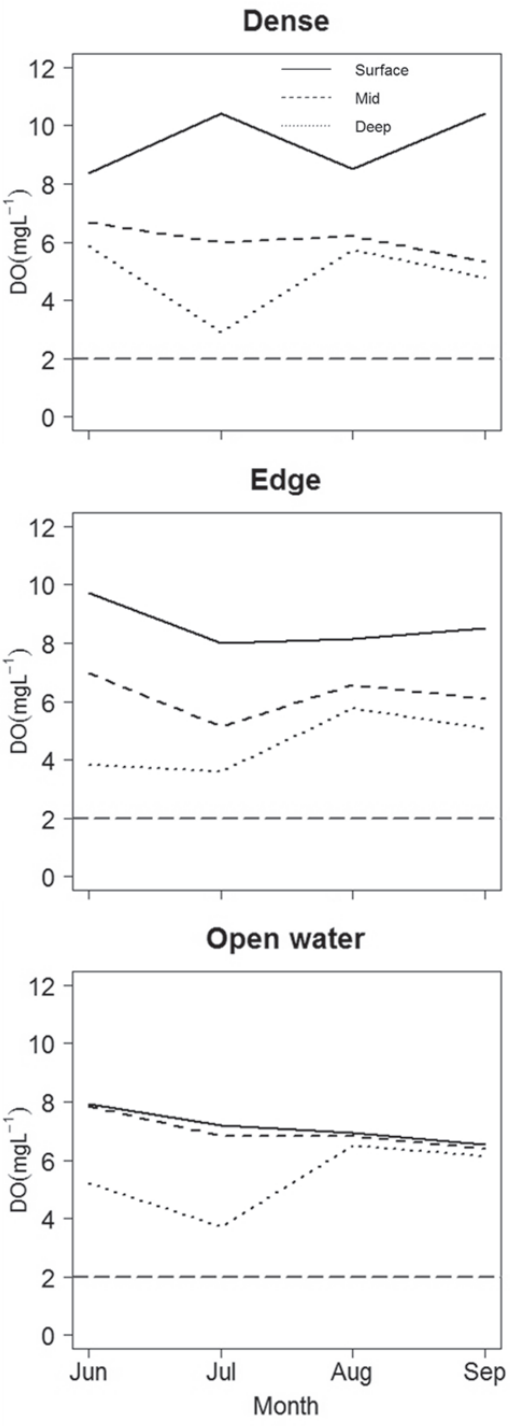


Figure 4. Afternoon mean dissolved oxygen concentrations (N=25) for dense, edge, and open water habitat types by month and depth at Lake Tohopekaliga, June – September

Discussion

Contrary to our expectations, edge habitat did not exhibit improved dissolved oxygen concentrations compared to dense habitat late in the summer season where hypoxia occurred (Sandmine Lake). In fact, the dense hydrilla bed showed similar or improved conditions compared to the edge habitat in late summer. This contrasts with the bay study by Miranda and Hodges (2000), who found dense macrophyte beds to be severely hypoxic (<1.0 mgL^{-1}) and the edge to have significantly improved DO concentrations. However, the negative gradient from open water into dense hydrilla was similar to Bunch et al. (2010) who found a negative gradient from open water into dense emergent plants.

The extensive hydrilla infestation at Sandmine Lake may have reduced water circulation in the open water and edge sampling areas (Carter et al. 1991; Miranda and Hodges 2000). Miranda and Hodges (2000) found dissolved oxygen concentration in edge habitat to have a negative relationship with overall macrophyte coverage of the bay. Water circulation increases nutrient availability and promotes oxygen production by phytoplankton (Frodge et al. 1990; Fee et al. 1992). Maximum hydrilla growth and widespread matting throughout resulted in minimal open water surface area, mainly only found in the mining area too deep for plant growth. If water movement is hindered by adjacent macrophyte beds, this could impact either open water or edge DO concentrations.

Dissolved oxygen did not decline to hypoxic levels at any depth or during any month in Lake Tohopekaliga. The large size and fetch of this lake is capable of generating substantial wave action, which increases water circulation (Stewart 1961) and probably maintained adequate DO concentrations. Additionally, Lake Tohopekaliga is a natural Florida lake and experiences gradual depth changes; this is contrasting to the man-made, sudden depth changes at Sandmine Lake which limits hydrilla growth in the deep mining area and creates a well-defined edge.

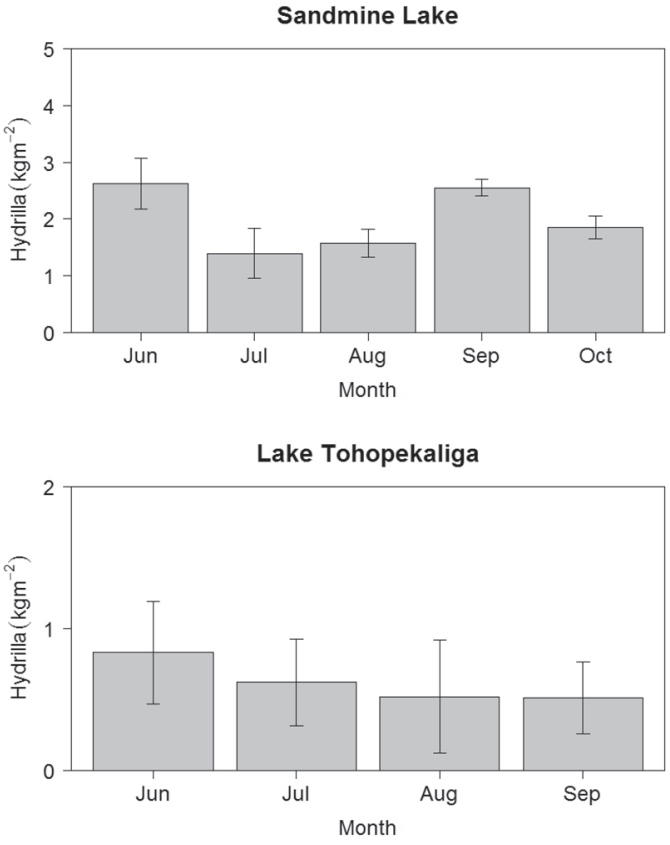


Figure 5. *Hydrilla* dry weight biomass samples (N=4) collected monthly from Sandmine Lake and Lake Tohopekaliga, June – September 2012. Note differing y-axes scales. Bars are standard error.

Vegetation biomass samples suggested that hydrilla in Sandmine Lake may have very spatially-dense root crowns and allocate growth energy to vertical stemming and surface branching.

The gradual depth changes in Lake Toho may allow hydrilla to lengthen rhizome growth between root crowns, taking advantage of horizontal expansion over vertical growth ("guerilla" strategy, McCreary 1991). Less-dense stemming and reduced hydrilla canopy may facilitate deeper sunlight transmission for photosynthesis and better water circulation. As the treatment and subsequent cost of hydrilla management is correlated with plant density (Koegel et al. 1977), this may be a consideration in management strategies of such differing lakes.

Depth significantly influences DO concentrations and thus fish habitat utilization and distribution throughout the water column.

Dissolved oxygen exhibited a negative relationship with depth during all months in both lakes; however it is not as significant in the absence of hypoxia at Lake Toho. Hypoxia in the deeper portions of the water column at Sandmine Lake is likely due to the decomposition of macrophyte and detritus material by aerobic bacteria and shading by the surface canopy, resulting in oxygen consumption and respiration rather than oxygen production (Cole 1994).

Complete hypoxia in the vegetated habitats was not for extended periods of time. Furthermore, we did not see evidence of fish kills on any sampling day when hypoxia was severe. Dissolved oxygen is positively correlated with fish abundance (Troutman et al. 2007) and thus has a significant influence over fish habitat utilization. Distribution of fish temporally (i.e., over hours of a day and seasonally), and spatially (i.e., vertically and horizontally) can fluctuate depending on water quality conditions (Suthers and Gee 1986; Miranda et al. 2000; Troutman et al. 2007). Fish alter their behavior when confronted with hypoxia by changing activity (reduced swimming rate and/or increased gill ventilation rate), air breathing (in bimodal species), increasing aquatic surface respiration, or by selecting new habitat by depth or migration (Kramer 1987). Suthers and Gee (1986) found yellow perch *Perca flavescens* to migrate from emergent vegetation when confronted with hypoxia. Contrastingly, Miranda et al. (2000) did not see a change in fish catch rates when dense submergent Southern naiad *Najas guadalupensis* became hypoxic, indicating a lack of migration. Moving from the hypoxic area to more suitable habitat can lead to overcrowding, decreased growth, and lower survival if adequate habitat is limited (Eby et al. 2005).

Alternatively, it has been widely shown that smaller fish have higher tolerance for low DO than larger fishes (Moss and Scott 1961; Burleson et al. 2001; Robb and Abrahams 2003). Consequently, small fish may not be excluded from hypoxic habitat, although this may limit their growth (Weber and Kramer 1983). Since vegetation growth is not uniform, microhabitats of elevated oxygen concentration may function as areas of refuge for fish during times of poor water quality (Miranda et al. 2000; Bunch et al. 2010).

Further study of fish community behavior and tolerance of adverse conditions in the natural environment would be beneficial for aquatic plant management decisions and strategies, as the occurrence of hypoxia over the summer season may impact how fish utilize these habitats spatially and temporally. The strategy selected by fish to manage hypoxia may largely depend on species and size. It is likely that smaller fishes (i.e., sunfish) utilize dense aquatic plant habitat more often than large predatory species (i.e., largemouth bass), which may prefer edge habitat (Barnett and Schneider 1974; Miranda and Hodges 2000). If smaller fishes are better able to manage hypoxia or possess coping mechanisms for low DO encountered seasonally in the environment, they may not be excluded from this habitat and vegetation removal may not be necessary. Ultimately, organisms will opt for whichever strategy requires the lowest energy expenditure, weighing the cost of migration, food resources, and risk of predation (Kramer 1987).

If management is required, macrophyte removal may only be needed for short, limited periods during times of high temperature and maximum macrophyte growth in late summer. Hypoxia was found only for part of the day due to diel fluctuation, and not a continual state. Submersed macrophytes provide valuable resources and support higher fish abundance and diversity than open water areas (Barnett and Schneider 1974). This habitat should be managed in a way to maintain some macrophyte coverage but also improve the overall ecosystem condition.

Our results also show that hydrilla beds from different lakes can experience very different dissolved oxygen dynamics. The size and morphology of the lake may influence overall DO concentrations. Sandmine Lake likely represents an extreme hydrilla infestation; however, with over 90 percent of Florida lakes considered small (<300 ha) (Shafer et al. 1986) and the prevalence of hydrilla in many of these systems, it is important to understand how severe hydrilla infestations affect dissolved oxygen concentrations in small lakes.

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