Syllabus - Freshwater 564
Water Quality in Aquaculture - Spring 2017

Instructors:  Ryan Newton, Ph.D., newtonr@uwm.edu, School of Freshwater Sciences

Class Meeting time & location: Tuesdays 1:00-3:40 PM, GLRF, School of Freshwater Sciences, Room 1080. This is a blended (hybrid) course; approximately one-half of the material will be presented online and the other half in the classroom.

Prerequisites: Students must have a junior standing or greater and completed classes in Biology (UWM Bio Sci 150 & 152), Chemistry (UWM Chem 102 & 104) or equivalent.

Course Description: This course is designed to give students an understanding of the ways in which water chemistry and microorganisms interact and ultimately impact water quality in intensive aquaculture systems. Emphasis will be placed on the principles of water chemistry, a fundamental understanding of microbiology related to aquaculture practices, monitoring and operational controls of water chemistry and microbial activities, and microorganisms that impact fish health. We will use a combination of online and in class presentations, discussions, and hands-on work to provide a foundation in water quality related technologies in intensive aquaculture. Topics will be explored in light of current practices and new developments in the field.

What is a blended (hybrid) course? Blended courses replace some portion of face-to-face meeting time with online learning activities and assignments. This design puts an emphasis on time and location flexibility for students but demands more personal responsibility to engage with course materials. Although more learning time is self-directed, all deadlines must be met for online assignments, exams, etc., and students must attend in-class meetings to get credit for materials and assignments presented. It is highly encouraged that students form working groups for studying and learning the online content.

Required for Course Interactions: To participate in the blended nature of this course, students must have at minimum daily access to a computer with an Internet connection. Many lectures, quizzes and exams, and group discussions will be posted and conducted in the Desire to Learn (D2L) platform hosted by UW-Milwaukee (At the UWM homepage http://uwm.edu, click on the D2L link). To interact with the online material, students will need a computer with audio capabilities and software that can open voice-over PowerPoint (VOP) lectures posted on D2L.

The online portion of this class will rely heavily on the D2L interface. Voiceover PowerPoint lectures will be posted on D2L and will require Windows Media Player (for *.wmv files on PC), QuickTime (for .M4V files playable on iOS devices) or VLC (for PC & Mac – available at http://www.videolan.org/vlc/index.html). Content and course instructions will be posted on D2L as .pdf files. Software such as Adobe Reader (free at http://get.adobe.com/reader/) capable of reading these files is necessary. It is recommended that students check e-mail and the D2L course homepage a few times a day for notifications. Most of the course material will be posted in the Content area and discussions will be facilitated through the Discussions area of the D2L course site. For technical help and technical contact information, see the UWM Help Desk (help@uwm.edu, 414-229-4040), http://www4.uwm.edu/technology/help/campus/gettechhelp.cfm, or go to Bolton Hall room 225 for an in-person consultation.
COVERED TOPICS

This class will cover foundations in water chemistry and microbiology that are pertinent to intensive aquaculture operation. Students will learn the principles of water chemistry and operational controls that impact water chemistry parameters in intensive aquaculture systems. Students also will learn about the fundamental properties of microorganisms and how these properties play a role in water quality maintenance. We expect students to connect water chemistry constraints and transformations to the microorganisms present, their growth constraints, and the community dynamics that govern chemical transformations in these systems. Additionally, students will explore the microorganisms that impact fish health and new research and approaches that focus on microbial systems health to improve aquaculture performance.

Learning Outcomes:

This course is designed so that students will learn:

- The water chemistry parameters of primary importance to intensive aquaculture systems
- A basic understanding of microorganisms and the nutritional requirements for microbial life in an aquaculture setting
- Microbial nitrogen transformations and how these apply to aquaculture
- Operational controls that impact water chemistry and therefore water quality outcomes
- Common water chemistry monitoring and measurement techniques
- The microorganisms of primary importance for water quality in intensive aquaculture
- The relationship between microbial communities and fish health

Upon completion students should be able to:

- Recognize and address complex water quality problems with operational control solutions
- Discuss and evaluate the principles of the nitrogen cycle in intensive aquaculture
- Have a foundational understanding of microorganisms and how they impact the operation of intensive aquaculture systems
- Have a basic understanding of laboratory techniques to measure water quality and quantify microorganisms in the system
- Understand the importance of microbial communities to aquaculture system health

Detailed Topic List

Water Quality – Water Chemistry

Basic properties of Water
- Properties as a polar molecule, etc.
- Water as a solvent
- Speciation of elements in water
- Water source considerations
**Important water chemistry parameters in intensive aquaculture**
- Intro to the basic parameters of importance: Temperature, Dissolved O$_2$, pH, Suspended solids, TAN, nitrate, nitrite, alkalinity, water hardness, and CO$_2$
- Ions and equilibrium reactions
- The contribution of fish food and fecal waste to water chemistry
- Dissolved Oxygen and Aeration
- pH and Alkalinity
- Carbon Dioxide
- Intensive Aquaculture design relationship to water chemistry

**Nitrogen in Intensive Aquaculture**
- Basic designs and goals of recirculating aquaculture biofilters
- Nitrification processes
- Biofilter design relationship to nitrification, including initiating & maintaining nitrification in biofilters
- Interactions between the N-cycle and other water parameters

**Measuring and Monitoring System Parameters**
- Wet-lab & on-site chemistry measurements
- Monitoring Sensors & Equipment
- System controls to maintain proper water chemistry
- Developing Technologies for Monitoring

**Integrating the RAS through water chemistry**
- How water chemistry connects all system units
- Examining the relationship between water chemistry variables & altering system parameters

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**Water Quality – Microbiology**

**What are microorganisms?**
- What are microorganisms and why study them in aquaculture?
- The diversity of microorganisms & characteristics defining the domains of microbial life.
- “Lifestyle” classification of microorganisms – basic physiology
- Important taxa in Intensive Aquaculture systems

**Methods for studying microorganisms in nature/built systems**
- Culture vs. Enrichment vs. Culture-Independent techniques
- Techniques for identifying/tracking microorganisms
- Techniques for measuring microbial activities

**Linking Water Chemistry to Microorganisms**
- Elemental composition of microorganisms – you are what you eat.
- Architecture of a microbial cell.
• Physical-Chemical constraints on microbial life
• Understanding microbial growth & relationship to Intensive Aquaculture operation
• The N-cycle and N-transformations mediated by microorganisms
• Biofilms and biofilm-inducing substrates

Common Disease causing Microorganisms in Intensive Aquaculture
• *Flavobacterium spp.* and associated disease
• Fungi, Viruses, and other disease causing microorganisms
• Detection, prevention, and monitoring methods

Microbiomes & Animal health
• The association between animals and their microbial communities, properties & benefits
• Current research in aquaculture and fish microbiomes, pro- & pre-biotics

Emerging Research Directions in the Field including Aquaponics Considerations

TIME COMMITMENT & SCHEDULE

Credits: This is a 3 credit-hour course. Students are expected to devote approximately 9 hours per week to the course over the semester. This time commitment will include:
• In-class time – lectures, hands-on (lab), and class discussions (21 hours)
• Listening/Watching online lectures & exploring online material (24 hours)
• Reading & study of assigned materials/lectures (60 hours)
• Participation in online discussions/problem sets (15 hours)
• Completion of online knowledge assessments (15 hours)
• Presentation and review article write-up on a class topic of interest including relevant primary literature (grad students only; 40 hours)
• Leading online & in-class discussions (grad student only; 8 hours)
• Exploring supplemental materials for topics to improve fundamental knowledge (as needed)

Course Structure: Note while effort has been taken to make this syllabus an accurate reflection of the course material, changes to its content are possible throughout the semester.

Week 1, Jan. 24: Intro to the Course – Lecture “Overview of Intensive Aquaculture and Water Quality Considerations” & “Basic properties of Water” (In Class)

Week 2, Jan. 31: Lecture “Introduction to Microorganisms” (Online)

Week 3, Feb. 7: Lecture & Lab “Basic water quality lab skills & “Culture-based methods for studying microorganisms in Intensive Aquaculture” (In Class)

Week 4, Feb. 14: Lecture “Important water chemistry parameters in intensive Aquaculture” & Finish Lab from Week 3. (In Class)

Week 5, Feb. 21: Lecture “Important water chemistry parameters in intensive Aquaculture cont.” “Nitrogen in Intensive Aquaculture” (Online) Quiz 1 - Week 1-4

Week 6, Feb. 28: Lecture “The Nitrogen cycle in Intensive Aquaculture” (Online)

Week 7, Mar. 7: Lecture & Lab “Measuring & Monitoring Water Quality Parameters” (In Class)
Week 8, Mar. 14: Lecture "Measuring & Monitoring Water Quality Parameters cont." (Online); Exam 1 - Weeks 1-7

Spring Break Mar. 21

Week 9, Mar. 28: Lecture "Linking Water Quality to Microorganisms" (Online)

Week 10, Apr. 4: Lecture & Lab "Molecular methods for detecting microorganisms" (In Class)

Week 11, Apr. 11: Lecture & Lab “Methods for detecting microorganisms & Disease causing microorganisms” (In Class), Quiz 2 - Weeks 8-10

Week 12, Apr. 18: Lecture "Microbes and animal health" & "Pre- & Pro-biotics" (Online)

Week 13, Apr. 25: Lecture "Wastewater remediation" & "Emerging Research in Intensive Aquaculture/Aquaponics", (Online)

Week 14, May 2: Lecture “Emerging Research in Intensive Aquaculture/Aquaponics cont.”, Student Presentations; and class review/wrap-up (In Class)

Week 15, May 9: No class, Exam 2 – Weeks 8-14

Finals Week – Mini-Review Paper Due May 16 at 11:59 PM

### Key Dates:

| In Class:      | Jan 24 – Week 1 | Apr 04 - Week 10 |
|               | Feb 07 - Week 3 | Apr 11 - Week 11 |
|               | Feb 14 - Week 4 | May 02 - Week 14 |
|               | Mar 07 - Week 7 |               |

| Quizzes/Exams – | Feb. 21 – Quiz 1 | Mar. 14 – Exam 1 |
|                | Apr. 11 – Quiz 2 | May 09 – Exam 2 |

**Final Project Undergrad Students – Literature-Review –Timeline:**

- Feb. 21 - Topic Chosen
- Mar. 07 - 5 or more appropriate references collected
- Mar. 28 – 10 or more appropriate references collected
- Apr. 25 – Rough draft of Presentation
- May 02 – Powerpoint presentation of selected topic

**Final Project Graduate Students - Mini-Review –Timeline:**

- Feb. 23 - Topic Chosen
- Mar. 07 - 10 or more appropriate references collected
- Mar. 28 – Rough draft of Introduction
- Apr. 25 – Rough draft of Mini-Review
- May 02 – Powerpoint presentation of Mini-Review topic
- May 16 – Mini-Review Final
**Evaluation:**
Final course grade will be a result of performance on exams, discussions (online & in-class), lab and primary literature write-ups, and an independent project mini-review article (grad only) and presentation. No Makeup assignments are anticipated.

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<tr>
<th>Assessment</th>
<th>Undergraduate</th>
<th>Graduate</th>
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<tr>
<td>Class Participation/Discussion</td>
<td>10%</td>
<td>4%</td>
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<tr>
<td>Literature &amp; Lab write-ups</td>
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<td>Quiz 1</td>
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<td>Quiz 2</td>
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<td>Exam 1</td>
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<td>Exam 2</td>
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<td>Discussion/Forum Leader</td>
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<td>Final Project Mini-Review</td>
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<td>Final Project Presentation</td>
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**Course Grade Scale:**
93-100% A; 90-92% A-; 87-89% B+; 83-86% B; 80-82% B-
77-79% C+; 73-76% C; 70-72% C-; 67-69% D+; 63-66% D; 60-62% D-; <60% F

*Exams/Quizzes* – Two short (quiz), and two longer exams will be administered in the class. The exams will cover the material up to that point in the class. Some exams may be administered online.

*Participation and Discussion* - grades will be a result of student engagement in online and in-class materials. Knowledge assessment tests will be administered online. Completion of these tests, participation during in-class group work, and posting to the discussion forums will be used to calculate the participation grade (see Sticky Subjects Forum document for posting requirements).

*Literature and Lab Write-ups* – For primary literature write-ups, on four to five occasions, students will be assigned to read and write about a primary scientific article, including its main points, how the work applies to aquaculture, what was unclear, what experiments could be carried out in the future, etc. For the lab write-ups, following three of the labs the students will relay their findings in a lab report format, including an introduction, results, and discussion section. For more details see D2L – Course Information.

*Final Project Presentation* – Undergraduate students will be required to select a specific lecture topic and prepare a 15 minute “powerpoint” presentation that more deeply explores the topic and relays information from the primary literature including state-of-the-art research directions. Presentations will be conducted during the last class period and will include evaluations from all students in the class. For more details see D2L – Course Information. Graduate students see below.
**Graduate Students:**
Graduate students will be required to select a specific lecture topic and prepare a review article style write-up and presentation that more deeply explores the topic and relays information from the primary literature including state-of-the-art research directions related to the topic. Presentations will be conducted during the last class period and will include evaluations from all students in the class. For more details see D2L – Course Information.

Graduate students also will be expected to lead at least one discussion in the online forum based on materials presented in the lectures, including asking pertinent questions and responding regularly to others posting comments.

Graduate students should expect additional quiz/exam questions that assess their synthesis of the material.

**Extra Credit:**
***Note the final review manuscript is required for graduate students only. Undergrads may choose to conduct the research project review for extra credit (maximum 10% increase in the final grade).***

**Course Policies:**
Attendance: With the exception of extreme emergencies, which require official documentation, class attendance is compulsory. Each missed class will result in a 5% decrease to the student’s final grade. If an absence is anticipated or in the case of an extreme event, then contact the instructors as soon as possible to discuss the problem.

Late assignments will be downgraded by 5% for each day past the due date.

Missed Exam Policy: There are no make-up exams, except for extreme emergencies, which require official documentation. In such an event, contact us as soon as possible to discuss the problem. Class presentations are considered examinations. An un-excused absence will result in lost points for that exam. Policies regarding final examinations can be found at the following: [http://www.uwm.edu/Dept/SecU/acad%2Badmin_policies/S22.htm](http://www.uwm.edu/Dept/SecU/acad%2Badmin_policies/S22.htm).

**Safety:**
This course requires some laboratory work. An initial safety introduction with material specific to the lab and classroom will be performed prior to the laboratory portions of the class. Work will include reagents that maybe a skin irritant and handling of bacteria cultures. Proper safety equipment will be provided during these labs.

**Suggested Learning Objective Resources:**
Learning in this course will rely heavily on reading of scientific literature. There is no assigned textbook. Required reading material for individual topics will be posted on D2L. Students may find any of the following textbooks as useful resources:


List of Required Reading:
Below is a list of the primary journal articles that students will be expected to read and discuss over the semester. Journal article readings will be assigned each week according to the learning objectives and material covered during that time. Note: this list is incomplete and subject to change as new materials become available.

Week 1:
- The Unique Properties of Water. Adapted from Campbell 1996 Biology (4th ed.)
- Cao et al., 2015. China’s aquaculture and the world’s wild fishes. Science 347:133-
- Martins et al., 2010. New developments in recirculating aquaculture systems in Europe: A perspective on environmental sustainability. Aquaculture Engineering 43:83-

Week 2:
- Blancheton et al., 2013. Insight into bacterial population in aquaculture systems and its implications. Aquaculture Engineering 53:30-

Week 3:
- Decostere et al., 1997. Shieh medium supplemented with tobramycin for selective isolation of Flavobacterium columnare (Flexibacter columnaris) from diseased fish. Journal of Clinical Microbiology 35:322-
- Zhang et al., 2014. Association of colony morphotypes with virulence, growth, and resistance against protozoan predation in the fish pathogen Flavobacterium columnare. FEMS Microbiology Ecology 89:553-

Week 4:
- Colt. 2006. Water quality requirements for reuse systems. Aquaculture Engineering 34:143-
- Roque d’orbcastel et al., 2009. Water quality and rainbow trout performance in a Danish model farm recirculating system: Comparison with a flow through system. Aquaculture Engineering 40:135-
- What is pH and How is it Measured? A technical handbook – Hach.

Week 5:

Week 6:
• Summerfelt et al., 2000. Oxygenation and carbon dioxide control in water reuse systems. Aquaculture Engineering 22:87-
• Zhang et al., 2015. Effect of using sodium biocarbonate to adjust the pH to different levels on water quality, the growth and the immune response of shrimp Litopenaeus vannamei reared in zero-water exchange biofloc-based culture tanks. Aquaculture Research 1-15.
• Durborow et al., 1997. Ammonia in fish ponds. SRAC Publication No. 463.
• Chen et al., 2006 Nitrification kinetics of biofilm as affected by water quality factors. Aquaculture Engineering 34: 179-

Week 7:
• Summerfelt et al., 2015. Effects of alkalinity on ammonia removal, carbon dioxide stripping, and system pH in semi-commercial scale water recirculating aquaculture systems operated with moving bed bioreactors.
• Stone et al., 2013. Interpretation of water analysis reports for fish culture. SRAC Publication No. 4606.

Week 8:
• Hüpeden et al., 2016. Relative abundance of Nitrotoga in a biofilter of a cold freshwater aquaculture plant appears to be stimulated by a slightly acidic pH-value. Applied and Environmental Microbiology
• Guerdat et al., 2010. An evaluation of commercially available biological filters for recirculating aquaculture systems. Aquaculture Engineering 42:38-

Week 9:
• Michaud et al., 2013. C/N ratio-induced structural shift of bacterial communities inside lab-scale aquaculture biofilters. Aquacultural Engineering.
• Racz et al., 2010. Effect of organic carbon on ammonia oxidizing bacteria in a mixed culture. Bioresource Technology 101:6454-

Week 10:
• Lennard. 2012. Aquaponic system design parameters: solids filtration, treatment and re-use.
• Smith & Osborn. 2009. Advantages and limitations of quantitative PCR (qPCR)-based approaches in microbial ecology. 67: 6-

Week 11:

Week 12:
• Declercq et al., 2013. Columnaris disease in fish: a review with emphasis on bacterium-host interactions. Veterinary Research 44:27.
• Cruz et al., 2012. Use of probiotics in aquaculture. ISRN Microbiology.

Week 13:
• Rakocy et al., 2006. Recirculating aquaculture tank production systems: Aquaponics – integrating fish and plant culture. SRAC Publication No. 454.
• Gutierrez-Wing et al., 2012. Evaluation of polyhydroxybutyrate as a carbon source for recirculating aquaculture water denitrification. Aquaculture Engineering 51:36-

Week 14:
• Mandiki et al., 2011. Effects of probiotic bacteria on growth parameters and immune defense in Eurasian perch Perca fluviatilis L larvae under intensive culture conditions. Aquaculture Research 42: 693-
• Llewellyn et al., 2014. Teleost microbiomes: the state of the art in their characterization, manipulation, and importance in aquaculture and fisheries. Frontiers in Microbiology 5:207.

Other Class Resources:
Class notifications. The course will be coordinated through e-mail and D2L. Reading material, class feedback and assignment delivery must be submitted by the due date using an official UWM email address. Please ensure that you check your official UWM e-mail and D2L frequently because you are responsible for all announcements and course changes posted there.

It is recommended that students use a high-speed internet connection to access D2L from off campus. If D2L content is not opening, examine the settings of your internet browser “pop-up-blocker” or switch internet browsers. Also be aware that timed assignments (e.g. quizzes/exams) do not stop if an internet connection is lost, so it is advised that students use a trusted internet connection and if possible a hardline connection.

The Library. Library work/access will be an important part of the course. In particular, the course will make use of the primary scientific literature (i.e. journal articles) so students will need to understand how to access this literature through library resources. See http://www4.uwm.edu/libraries/ (Specific Journal Titles dropdown menu for journal access). Google Scholar also may be of use to search for articles of interest (http://scholar.google.com).

Class Notes: You are responsible for your own note taking: taking notes is an essential part of the learning process.

General Course/Campus Policies:
Students with Special Needs: Students with special needs should arrange to speak with the instructor(s) during the first week of classes so we can best accommodate your learning style. Note University Policies: Students with disabilities. Verification of disability, class standards, the policy
on the use of alternate materials and test accommodations can be found at the following:
http://www.uwm.edu/Dept/DSAD/SAC/SACltr.pdf

Students with disabilities. Verification of disability, class standards, the policy on the use of alternate materials and test accommodations can be found at the following:
http://www.uwm.edu/Dept/DSAD/SAC/SACltr.pdf

Religious observances. Policies regarding accommodations for absences due to religious observance are found at the following:
http://www.uwm.edu/Dept/SecU/acad%2Badmin_policies/S1.5.htm

Students called to active military duty. Accommodations for absences due to call-up of reserves to active military duty should be noted.
http://www3.uwm.edu/des/web/registration/militarycallup.cfm

Incompletes. The conditions for awarding an incomplete to graduate and undergraduate students can be found at the following:
http://www.uwm.edu/Dept/SecU/acad%2Badmin_policies/S31.pdf

Discriminatory conduct (such as sexual harassment). Definitions of discrimination. Harassment, abuse of power, and the reporting requirements of discriminatory conduct are found at the following:
http://www.uwm.edu/Dept/SecU/acad%2Badmin_policies/S47.pdf

Academic misconduct. In this course, you are expected to perform to the best of your ability in an honest manner. Cheating, plagiarism, or other acts of misconduct will result in a severe penalty to you, as per University of Wisconsin System Chapter 1.
http://www.uwm.edu/Dept/OSL/DOS/conduct.html Plagiarism is a particular concern: many students seem unclear about what it involves. I recommend that you read:
http://www.plagiarism.org/learning_center/what_is_plagiarism.html because ignorance is not acceptable as an excuse.

Complaint procedures. Students may direct complaints to the head of the academic unit or department in which the complaint occurs. If the complaint allegedly violates a specific university policy, it may be directed to the head of the department or academic unit in which the complaint occurred or to the appropriate university office responsible for enforcing the policy.

Grade appeal procedures. Procedures for student grade appeal appear at the following:
http://www.uwm.edu/Dept/SecU/acad%2Badmin_policies/S28.htm

Final examination policy. Policies regarding final examinations can be found at the following:
http://www.uwm.edu/Dept/SecU/acad%2Badmin_policies/S22.htm