COVER SHEET FOR GRANT PROPOSALS

State Board of Education

SBOE PROPOSAL NUMBER: (to be assigned by SBOE)	AMOUNT REQUESTED: $50,000

TITLE OF PROPOSED PROJECT:

COMMERCIALIZING SPECIFIC PROBIOTIC BACTERIAL STRAINS AS DIRECT FED MICROBIALS (DFMs) TO IMPROVE FISH HEALTH AND REDUCE DISEASE RELATED MORTALITY AT AQUACULTURE FACILITIES

SPECIFIC PROJECT FOCUS:
Aquaculture development

PROJECT START DATE:3/2011	PROJECT END DATE:3/2012
NAME OF INSTITUTION: University of Idaho	DEPARTMENT: Fish and Wildlife
ADDRESS: PO Box 441136, Moscow, ID 83844-1136	

	E-MAIL ADDRESS: kcain@uidaho.edu	PI PHONE NUMBER: 208-885-7608

	NAME:	TITLE:	SIGNATURE:
PROJECT DIRECTOR	Kenneth Cain	Associate Professor	
CO-PRINCIPAL INVESTIGATOR	Mike McCollough	Associate Professor	
CO-PRINCIPAL INVESTIGATOR			
CO-PRINCIPAL INVESTIGATOR			

	NAME:	SIGNATURE:
Authorized Organizational Representative	**Polly J Knutson, Director Office of Sponsored Programs University of Idaho**	CK 12/2/10

SUMMARY PROPOSAL BUDGET

Name of Institution: University of Idaho

Name of Project Director: Kenneth Cain

A. FACULTY AND STAFF

Name/ Title	Rate of Pay	No. of Months CAL	ACA	SUM	Dollar Amount Requested
Kenneth Cain	50.30/hr			1	8,050
% OF TOTAL BUDGET: 16.2				**SUBTOTAL:**	8,100

B. VISITING PROFESSORS

Name/ Title	Rate of Pay	No. of Months CAL	ACA	SUM	Dollar Amount Requested
% OF TOTAL BUDGET:				**SUBTOTAL:**	

C. POST DOCTORAL ASSOCIATES / OTHER PROFESSIONALS

Name/ Title	Rate of Pay	No. of Months CAL	ACA	SUM	Dollar Amount Requested
% OF TOTAL BUDGET:				**SUBTOTAL:**	

D. GRADUATE / UNDERGRADUATE STUDENTS

Name/ Title	Rate of Pay	No. of Months CAL	ACA	SUM	Dollar Amount Requested
David Burbank or TBA	16.07/hr	7			8,999
% OF TOTAL BUDGET: 18				**SUBTOTAL:**	9,000

E. FRINGE BENEFITS

Rate of Pay (%)	Salary Base	Dollar Amount Requested
23%	78,478	1,851
1%	16,712.80	90
	SUBTOTAL:	1,900

F. EQUIPMENT: (List each item with a cost in excess of $1000.00.)

Item/Description	Dollar Amount Requested
10L single wall Fermentor	20,443
SUBTOTAL:	20,400

G. TRAVEL:

Dates of Travel (from/to)	No. of Persons	Total Days	Transportation	Lodging	Per Diem	Dollar Amount Requested
6/2011 From Moscow to Utah	1	4	45/day plus fuel	Approx. 100/day	30/day	1,000
8/2011 From Moscow to S. Idaho	1	5	45/day plus fuel	Approx. 100/day	30/day	1,000
11/2011 From Moscow to Utah	1	4	45/day plus fuel	Approx. 100/day	30/day	1,000
					SUBTOTAL:	3,000

H. Participant Support Costs:

	Dollar Amount Requested
1. Stipends	
2. Travel (other than listed in section G)	
3. Subsistence	
4. Other	

SUBTOTAL:	
I. Other Direct Costs:	Dollar Amount Requested
1. Materials and Supplies (media, reagents, glassware, etc.)	7,596
2. Publication Costs/Page Charges	
3. Consultant Services (Include Travel Expenses)	
4. Computer Services	
5. Subcontracts	
6. Other (specify nature & breakdown if over $1000)	
SUBTOTAL:	7,600
J. Total Costs: (Add subtotals, sections A through I) **TOTAL:**	50,000
K. Amount Requested: **TOTAL:**	50,000
Project Director's Signature:	Date: 12/1/10

SBOE Idaho Incubation Fund Program Proposal

COMMERCIALIZING SPECIFIC PROBIOTIC BACTERIAL STRAINS AS DIRECT FED MICROBIALS (DFMs) TO IMPROVE FISH HEALTH AND REDUCE DISEASE RELATED MORTALITY AT AQUACULTURE FACILITIES

EXECUTIVE SUMMARY: Aquaculture is currently the fastest growing sector of agriculture and now accounts for at least half of the seafood consumed worldwide. Idaho leads the world in commercial foodfish production of rainbow trout with nearly 80 private facilities in southern Idaho alone and a value of up to $100 million/yr. Disease outbreaks can have dramatic consequences in aquaculture and one of the most serious disease affecting trout and salmon production in the region (and worldwide) is coldwater disease (CWD) caused by the bacterium *Flavobacterium psychrophilum*. This disease is regarded as the number one problem for the Idaho trout industry, with losses averaging nearly 30% and costing the industry $9-10 million annually in direct mortality alone. Public and tribal hatcheries rearing steelhead and salmon also lose more fish to CWD than any other disease. Novel approaches to combat this disease and improve fish health in general are needed. One such approach that is gaining interest in aquaculture involves the use of probiotics (microbial feed additives that provide health benefits). A probiotic (also referred to as Direct Fed Microbial or DFM) can consist of "normal" intestinal bacteria that inhibit or outcompete the growth of specific pathogens of interest. Such DFMs could provide an alternative to antibiotic therapy or complement vaccination and/or other disease management strategies. Our lab has recently identified two probiotic bacterial strains (C6-6 and C6-8) that, when fed to rainbow trout, significantly improve fish health as measured by reduce mortality to CWD.

This proposal requests incubation funds to support late-stage prototype testing for DFM production and additional field testing that is essential for the licensing of a DFM for use in salmonid

(trout and salmon) aquaculture. Focus will be on the creation of a start-up company to license the DFM from the University of Idaho (UI) and first market the DFM to public and private sector aquaculture operations in Idaho and the Pacific Northwest.

"GAP" PROJECT OBJECTIVES AND TOTAL AMOUNT REQUESTED: We are seeking $50,000 of incubation funds to conduct prototype testing on C6-6 and C6-8 production and expand upon previous field trial testing. The prototype will advance the technology readiness level (TRL) to 7 and may be used for limited DFM production for the start-up company. Specific project objectives will determine optimum bacterial growth and storage conditions, and further evaluate health benefits when fed to fish. We have tested our C6-6 strain in both the lab and under production conditions in the field (see Technology section below) but have only tested C6-8 under laboratory conditions. It will be important to expand our work to include field testing of C6-8. It is likely that a DFM using a mixture of C6-6 and C6-8 will provide the most benefit; however, such a mixed product must be tested. Therefore, the objectives of this "Gap" project are to:

1. Optimize growth and production parameters for C6-6 and C6-8.
    a. Scale up current conditions to 10L or more using a laboratory scale fermentor.
    b. Optimize aeration, temperature, and inoculation conditions to maximize growth.
2. Determine appropriate storage conditions to minimize loss in bacterial viability while keeping costs at a minimum.
    a. Concentrate bacteria in Fish Oil (currently used when mixing into feed) and test viability following storage (-20°C).
    b. Test lyophilization (freeze drying) of bacteria as an alternative.
3. Test equal mixtures of C6-6 and C6-8 under laboratory and field conditions their ability to reduce CWD.

4. Test feeding frequency and dose requirements to achieve desired benefits.
5. Develop a complete business plan.

INSTITUTION: University of Idaho

FACULTY MEMBER DIRECTING PROJECT: Project Director: Ken Cain, Department of Fish and Wildlife Resources and the Aquaculture Research Institute, University of Idaho, Moscow, ID 83844-1136

Co-PI: Mike McCollough, College of Business and Economics, University of Idaho, Moscow, ID 83844-3161

Student marketing team (UI): Brian Bialke, Jessica Bargman, Ryan Barrie, Kristen McGee, Carl Marrow, Richard Pendegraft, Brett Watterson, David Ziong.

PROJECT RELATIONSHIP TO HOME INTITUTION PRIORITIES: This project fits well with the priorities of the UI and aligns with specific signatures areas of research (Nexus of energy production and use, agriculture and the environment; Real time evolution) identified and associated with the strategic plan of the UI. Promotion of entrepreneurial activities, development and commercialization of products, and technology transfer to public and private sector entities is an important priority of the UI as a land grant institution.

POTENTIAL IMPACT TO IDAHO ECONOMY: There are a number of potential impacts to Idaho's economy that commercialization of this product could provide. In the private sector, aquaculture represents a major industry in Idaho and supplies approximately 80% of the commercially produced rainbow trout in the US. Disease related impacts affect over 30% of their production on average. The ability to reduce such impacts, even by a small margin, would translate to a direct economic benefit and greater revenue for Idaho companies. In addition, this product would be widely used by public sector (State, Federal, and Tribal) aquaculture facilities rearing trout and salmon for Sportfishing and/or recovery of endangered/threatened stocks.

Again, reduced cost of production for State hatcheries and increased opportunities of Sportfishing harvest of trout and salmon would have direct benefit for Idaho and its citizens. Public and private sector aquaculture represents a large potential market and creation of a new start-up company in Idaho would directly benefit Idaho's economy and create jobs.

PARTNERSHIPS OR NEW COMPANY CREATION: The focus will be on the creation of a new start-up company that would produce, market, and distribute this DFM product to public and private aquaculture producers in Idaho and the region. The patent protected technology will be licensed from the UI to this new company. Clear Spring's Foods, Inc., an Idaho company, and the world's largest commercial producer of rainbow trout, has expressed an interest in collaborating with UI with regards to market penetration of this product line (see Appendix). Although Clear Spring's Foods does not wish to become a producer of the DFM themselves, they are excited to see this product successfully enter the marketplace.

For product field testing we have and will continue to collaborate with Clear Spring's Foods, Inc. in Southern Idaho and the Utah Division of Wildlife Resources. We are also working with the Idaho Department of Fish and Game in other areas and if needed we will expand field testing to State hatcheries in Idaho. These partnerships represent private and public sector hatcheries suffering high losses to CWD.

MARKET OPPORTUNITY: Need project would address: The need to reduce disease impacts in aquaculture and reduce reliance on antibiotics would be addressed by this project. The use of natural antibiotic replacers, such as a DFM, has been identified as a major market driver across the animal feed market spectrum (Frost & Sullivan, 6 Aug 2010).

Applications and markets for the technology: A DFM can be easily applied to fish feed and delivered to large numbers of fish. The markets for this technology include all fish hatcheries

rearing trout and salmon. Frost & Sullivan reported that in 2006 the total US animal feed DFM market was valued at $148.5 million, with aquaculture DFM use at 5%, an immature but growing market segment. By 2013 the animal feed DFM market is expected to reach $272.2 million, with aquaculture DFMs reaching 30% of the total.

Product description, potential market audience, competition, and market barriers: The product would be a DFM sold in a form that could be mixed directly into fish feed. The market audience would be large and include public and private sector aquaculture facilities. Over 100 million fish could be administered this DFM annually in Idaho and the Pacific Northwest alone. As reported by Frost & Sullivan, most of the US competitors are small companies that are able to create the fermented product and sell directly to the end-user. Market barriers may include unforeseen regulatory requirements, producer concerns over application requirements (i.e. mixing into feed), and a general lack of awareness of DFMs in the industry. Recent discussions with Ag Program Specialists at the Idaho USDA have reduced our concerns regarding regulatory barriers. A recent market analysis by UI students in the College of Business and Economics included a survey of Idaho producers that suggested other potential barriers, such as feed application, are minimal. This analysis included a suggested product price of $180 to treat 100,000 fish, which represents an estimated gross revenue of at least $90/100,000 fish. Current treatment with antibiotics cost $200/100,000 fish.

TECHNOLOGY:

Current state of technology: We have tested 318 bacterial strains isolated from the GI tract of rainbow trout for their ability to inhibit growth of *F. psychrophilum*. At this point, two candidate probiotics (C6-6 and C6-8) capable of reducing mortality related to CWD when used as live microbial feed additives have been discovered. Initial experiments using C6-6 showed that fish

fed aggressively and exhibited no mortality following challenge with *F. psychrophilum* (Figure 1). In repeated experiments, feeding of C6-6 to fish has consistently resulted in a significant reduction in mortality due to CWD when compared to controls. A second isolated probiotic (C6-8) was recently identified that also demonstrated a significant reduction in mortality compared to control groups. Both of these two probiotic strains have been identified as different *Enterobacter spp.* Genetic sequence information is being obtained that will distinguish between the two and confirm their relationship to known species within this genus. In addition to laboratory trials, we have field tested C6-6 at fish hatcheries in Utah. Figure 2 shows data from one such trial. However, in three separate hatchery trials, rainbow trout fry were fed our probiotic and in each case mortality was reduced by nearly 50% following a natural outbreak of CWD. Such results are exciting and clearly demonstrate the commercial potential of these bacteria for use as probiotics in aquaculture.

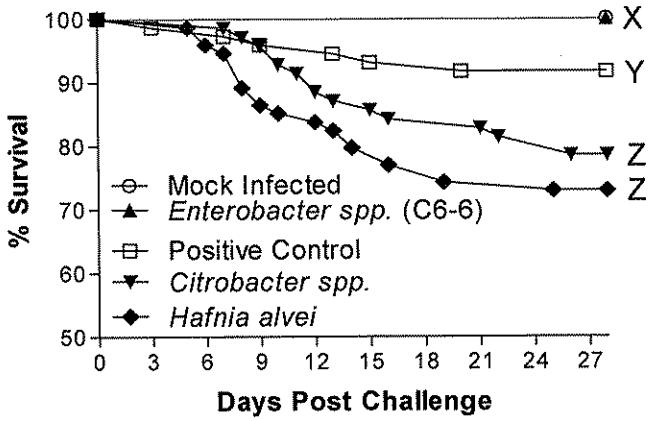


Figure 1. Probiotic effectiveness at reducing mortality due to an infection of *F. psychrophilum*.

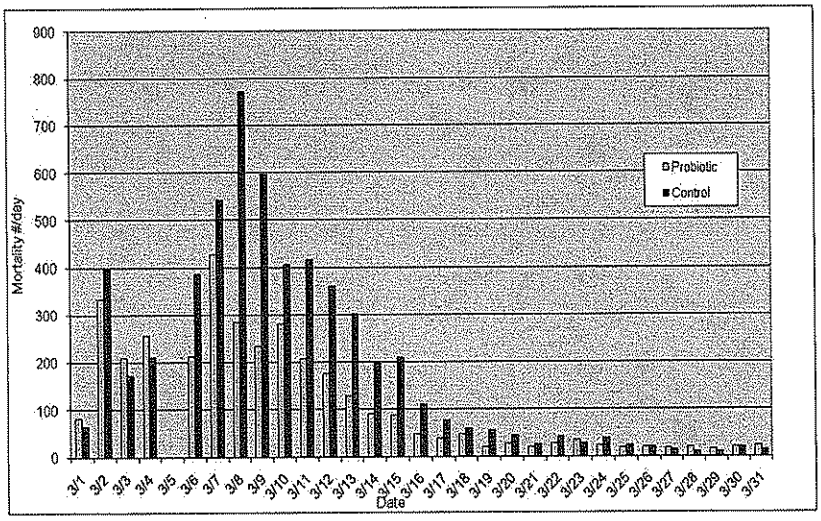


Figure 2. Field testing of C6-6 or a control feed at the Utah Fisheries Experiment station hatchery showing daily mortality of rainbow trout.

Product and market need/intellectual property status: There is a strong need to develop and commercialize these probiotics as a DFM for aquaculture. This could provide a replacement for antibiotic use, and be easily administered as a simple feed additive mixed into feed on-site. . Alternatively, aquaculture feed companies could be contracted to produce feed pellets that are "top-coated" with the DFM and then sold directly to the producer. In either case, this product provides a new disease control strategy that is easily delivered to a large number of fish.

A case number has been assigned to C6-6 through the UI Office of Technology Transfer and we plan to move forward with a provisional patent application that will likely include both C6-6 and C6-8.

Potential customers: Since we have shown that a DFM can enhance the health status of fish and in the process demonstrated efficacy for controlling CWD, the number of potential customers includes all aquaculture operations that rear trout and salmon in the US and worldwide. The Idaho trout industry would immediately benefit from this product and it would provide a substantial economic benefit to producers through reduced fish mortality. Beyond this, all federal, state, and tribal hatcheries rearing steelhead and salmon would be potential customers. This product would provide a direct economic benefit to the state of Idaho by reducing disease related costs and improving production capabilities at private and public sector aquaculture facilities.

Who developed technology and with what funding: The technology was developed/discovered by Dr. Kenneth Cain and graduate student David Burbank. Direct funding for this project has been provided through USDA and the WSU/UI Aquaculture Initiative and a student scholarship and research award through the University's McNair Scholar Program.

Theoretical soundness of project: This project is theoretically and practically sound and represents a very applied approach that would be readily accepted by aquaculture producers.

Maturity of science/technology: The use of probiotics in human and livestock is well established, but the use of probiotic bacteria as DFMs in aquaculture is in its infancy. As discussed in Market Opportunity, aquaculture DFMs have been an immature but growing segment of the overall animal feed DFM market.

Hardware development and integration risk: No hardware was developed to produce this product and there is no integration risk.

Maturity of system: The technology is mature in that C6-6 and C6-8 have been shown to readily replicate, can be stored and then easily applied to feed. The system now requires scale-up. Due to previous lab and field testing C6-6 is further advanced than C6-8; TRL of 5 versus a TRL of 4. The incubation funds will advance the technology to TRL levels of 8 and 7, respectively.

Viability of the technology: The technology is viable in that our bacterial strains grow rapidly, are harvested and stored easily, and can be readily applied to fish feeds.

COMMERCIALIZATION PARTNERS:

Commercial partners: Our goal is to create a start-up company. This company will license our DFM from the UI and then directly market, produce, and sell this product. Clear Spring's Foods, Inc. has expressed an interest in collaborating with UI with regards to market penetration of this product line (see Appendix). If creation of a start-up company is not deemed feasible, then we will seek an industry partner to commercialize the DFM. Invervet/Schering-Plough and Aquatic Life Sciences have shown interest in this product and have already signed non-disclosure agreements with UI.

SPECIFIC PROJECT PLAN AND USE OF FUNDS: We plan to complete the final stages of laboratory and field testing for C6-6 and C6-8 as outlined in the "Gap" project objectives section. Such trials will assess mortality as well as fish growth and performance during a production

cycle. Funds will also be used to conduct critical laboratory experiments to address storage requirements and optimize bacterial growth conditions for scale-up of probiotic production.

Proposed budget:

Expenditure	***March – June '10***	***July –February'11***
Salaries/wages		
Graduate Student(MS student)	3,857	5,142
(Fringe @ 1%)	39	51
Project Director (approx. one month)		8,048
(fringe@23%)		1,851
Equipment (Lab scale Fermentor –see attached quote)	20,443	
Materials and Supplies (media, glassware, fish feed, fish oil, etc.)	3,569	4,000
Travel	1,000	2,000
Total:	**28,908**	**21,092**

Funds requested will support the project director (approximately one month) to oversee laboratory trial and assist with field trials. A graduate student will be supported at the current M.S. rate (16.07/hr for 20 hrs/wk) for seven months to conduct lab experiments. Material and supply costs and equipment costs associated with purchase of a lab-scale fermentor are included.

Research Timeline 2010-11	M	A	M	J	J	A	S	O	N	D	J	F
Acquire Lab Scale Fermentor	■	■	■									
Optimize fermentor production		■	■	■								
Laboratory trials (mixed culture/dose studies, growth and storage, etc.)	■	■	■	■	■	■	■					
Field trial expansion (mixed culture, dose and feeding frequency, etc.)				■	■	■	■	■	■	■		
Business Plan development, patent applications, etc.	■	■	■	■	■	■	■					
Start-up company planning or establishment of commercialization partners						■	■	■	■	■	■	
Product Launch												■

Travel support from Moscow to southern Idaho and Utah hatcheries is requested and it is anticipated that 3 trips will be made over the course of this project.

EDUCATION AND OUTREACH: This project will have a strong education component. Students in Dr. McCollough's Product Development course have completed a quantitative market research on this product, have developed a market report and will enter the UI Spring semester business plan competition. The Co-PI (Dr. McCollough) has mentored these students since January 2010 and will continue to work directly with them to develop a solid business plan. The partnership with the business school provides valuable entrepreneurship educational training for university students. In addition, several students involved in this project have expressed an interest in working for this start-up company.

We will work closely with the University of Idaho's Aquaculture Extension Specialist Gary Fornshell to communicate with public and private sector "customers" and highlight the product and its potential benefit. This outreach component will include presentations at the Idaho Aquaculture Association annual meeting and/or a possible disease workshop for the industry applied in a "real world" hatchery setting. Mr. Fornshell is well respected in the industry and the Project Director (Dr. Cain) has worked with him extensively in the past to develop and present workshops relevant to disease management at aquaculture facilities.

INSTITUTIONAL AND OTHER SECTOR SUPPORT: Throughout this project we will work closely with the Office of Technology Transfer to protect the UI's rights and assist in the creation of a start-up company. In addition, we have both public and private sector support (see attached letters) essential for testing product under "real world" conditions. These partners include the Utah Division of Wildlife Resources and Clear Spring's Foods, Inc.

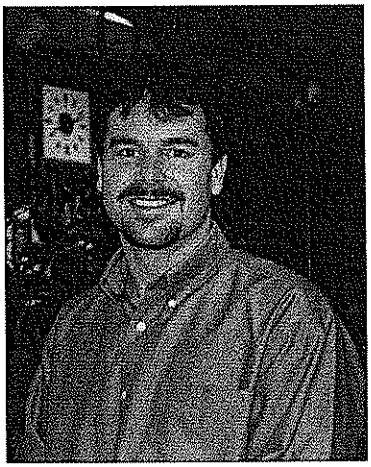
APPENDICES:

FACILITIES AND EQUIPMENT: The Fish Health Lab at the University of Idaho is designed as a pathology, diagnostic and immunology laboratory. Equipment available includes low temperature incubators, microcentrifuges, ultracold freezer, fume hoods, laminar flow hoods, PCR machine, Protean IEF system (Bio-Rad) for 2D-PAGE, and DNA electrophoresis and Western blotting equipment. In addition, a DNA sequencer, gel imager, and other equipment along with trained personnel are available within the Molecular Biology Core Laboratory in the Department of Fish and Wildlife Resources. Wet Lab space for fish rearing and holding is available and located within the Fish and Wildlife Department, at Aquaculture Research Institute's Wet Lab, and at the U of I Hagerman Fish Culture Experiment Station. All water exiting the U of I campus facility is directly discharged to the Moscow water treatment plant where complete disinfection occurs.

BIOGRAPHICAL SKETCHING AND INDIVIDUAL SUPPORT:

University of Idaho

College of Natural Resources



Kenneth Cain

Associate Professor, Department of Fisheries Resources
E-mail: kcain@uidaho.edu
Web: http://www.cnrhome.uidaho.edu/default.aspx?pid=72846

Office: Room 105 D, College of Natural Resources
Phone: (208) 885-7608

Education

- Ph.D. Animal Sciences, Washington State University (1997)
- M.S. Fish and Wildlife, Michigan State University (1993)
- B.S. Fish and Wildlife, Michigan State University, East Lansing (1990)

Specialty Areas of Interest:

- Fish immunology/Host-pathogen interactions
- Aquaculture vaccine and probiotic development
- Disease diagnostic assay development
- Conservation/commercial aquaculture expansion for new species

Five Relevant Publications:

- Cain, K.D and Swan, C.M. 2010. Barrier Function and Immunology. "The Multifunctional Gut of
  Fish" Elsevier Inc., (Invited book chapter), *Fish physiology* vol: 30, 112-134.

- Lindstrom, N.M., Call, D.R., House, M.L., Moffitt, C.M., and Cain, K.D. 2009. A quantitative enzyme-linked immunosorbent assay (ELISA) and filtration-based fluorescent antibody test (FAT) as potential tools to screen broodstock for *Flavobacterium psychrophilum* infection. *Journal of Aquatic Animal Health* 21(1): 43-56
- LaFrentz, B.R., LaPatra, S.E., Call, D.R.., and **Cain, K.D.** 2008. Development and characterization of rifampicin resistant *Flavobacterium psychrophilum* strains and their potential as live attenuated vaccine candidates. *Vaccine* 26 (2008) 5582–5589
- Swan, C. M., Lindstrom, N. M., **Cain, K. D**. 2008. Identification of a localized mucosal immune response in rainbow trout *Oncorhynchus mykiss* following immunization with a protein-hapten antigen. *Journal of Fish Diseases* 31, 383-393
- **Cain, K.D.** and LaFrentz, B.R. Laboratory Maintenance of *Flavobacterium*. 2007. Current Protocols in Microbiology (Book chapter – Invited), 6:13B.1.1-13B.1.12

Current and Pending Support - Cain

SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	%OF TIME COMMITTED	TITLE OF PROJECT
Active:				
USDA/CREES – WSU/UI Aquaculture Initiative	$590,000 (50% at UI)	10/05-10/12	7	Comparative genomics and proteomics of *Flavobacterium psychrophilum* moving toward vaccine development
USDA/CREES – WSU/UI Aquaculture Initiative	$35,000yr1 + $34,987yr2+ $30,000yr3	10/04-10/07 (NCE – 9/09) (9/09-9/11)	5	Development of autochthonous probiotics to control fish diseases in aquaculture
USDA/CREES – WSU/UI Aquaculture Initiative	$28,000	1/10-1/11	4	Understanding innate defence mechanisms to enhance control strategies for infectious hematopoietic necrosis virus in rainbow trout
Kootenai Tribe of Idaho (BPA)	$558,935	11/05-1/11	8	Development of Burbot (*Lota lota*) conservation aquaculture and evaluation of disease susceptibility
Western Regional Aquaculture Center	$325,000	10/07-10/12	5	Coldwater disease prevention and control through vaccine development and diagnostic improvements
USFWS	$66,000	10/07-10/11	2	Development and Evaluation of Extensive Larval and Juvenile Rearing Techniques and Systems for Burbot (*Lota Lota maculosa*) to meet Conservation Aquaculture Needs
USDA/CREES – WSU/UI Aquaculture Initiative	60,000 (25,000 to UI)	1/09-1/11	2	Identifying the etiologic agent of Strawberry Disease in rainbow trout
NSF	$600,000	7/09-7/11	2	Transforming environmental and physiological assessments using fish erythrocyte gene expression to measure responses
USDA/SBIR	$100,000 ($25,000 UI)	10/10-10/11	2	Development of High Sensitivity and Specificity Quantitative Aptamer Assay for Coldwater Disease Management Applications
LiveLeaf BioSciences (Research service agreement)	$5,489	10/10-4/11	1	Pilot testing of potential phyto-therapeutics for inhibition of bacterial pathogens important to aquaculture
USDA	$234,956	9/09-9/11	2	Converting Alaska fish byproducts into value added ingredients and products
Pending:				
USFWS	$89,630	1/11-1/13	3	Development of Techniques to Culture Pacific Lamprey in the Snake River Basin
LSRCP/USFWS	$70,404	1/11-1/13	3	Understanding *Nucleospora salmonis* infections in wild and hatchery fish to develop strategies to limit transmission and spread

Dr. Michael A. McCollough
Associate Professor of Marketing
VIEW (Vandal Innovation and Enterprise Works) Director
College of Business and Economics, P.O. Box 443161
Moscow, Idaho 83844-3161
Phone: 208.885.7151; Fax: 208.885.8939; E-mail: mccollou@uidaho.edu

Education:
Ph.D., Business Administration, 1995, Texas A&M University, College Station, Texas.
M.B.A., 1982, The Ohio State University, Columbus, Ohio.
B.S., Business Administration, 1980, The Ohio State University, Columbus, Ohio.

Non-Academic Employment: The May Ohio Company/The M. O'Neil Company (May Department Stores)
Branch Store Divisional, September 1997 – August 1990
Buyer, March 1985-August 1987
Assistant to President and Chairman, February 1984-February 1985
Assistant Buyer, February 1983-January 1984.

Teaching Areas of Specialization
Marketing Management, Services Marketing, Retail, Integrated Business Curriculum, EMBA, Strategic Management, Vandal Solutions

Relevant Publications

- McCollough, Michael A. "Service Guarantees: A Review And Explaination Of Their Continued Rarity," *Academy of Marketing Studies Journal*, forthcoming.
- McCollough, Michael A. 2009. "The Recovery Paradox: The Effect of Recovery Performance and Service Failure Severity on Post-Recovery Customer Satisfaction," *Academy of Marketing Studies Journal*, 3(1), 89-104.
- Lawrence, John J. and Michael A. McCollough. 2007. "The Lewis Group and the Esprit Franchise in New Zealand", *Journal of International Business Education* 3(1), 1-9.
- Lawrence, John J. and Michael A. McCollough. 2004. "Implementing Total Quality Management in the Classroom By Means of a Student Satisfaction Guarantee" *Total Quality Management and Business Excellence* 15(2): 235-254.
- McCollough, Michael A and Dwayne D. Gremler. 2004. "A Conceptual Model and Empirical Examination Of The Effect Of Service Guarantees On Post-Purchase Consumption Evaluations" *Managing Service Quality*, vol. 14, No 1, 58-74.
- Gremler, Dwayne D. and Michael A. McCollough. 2002. "Student Satisfaction Guarantees: An Empirical Examination of Attitudes, Antecedents, and Consequences." *Journal of Marketing Education*, (December).
- McCollough, Michael A., Leonard L. Berry, and Manjit S. Yadav. 2000. "An Empirical Investigation of Customer Satisfaction after Service Failure and Recovery." *Journal of Service Research*, 3 (November), 121-137

Grants and Contracts Awarded:
University of Idaho College of Business and Economics:

- Faculty Excellence Award, $10,000 awarded 2008
- Alsaker Family Fellowship, $15,000 awarded 2007
- First Security Fellowship, $10,000 awarded 2003 for 2003, 2004, 2005.
- University of Idaho $8,000 Seed Grant Fiscal Year 2002
- University of Idaho $6,000 Seed Grant, Fiscal Year 2000.
- Summer Research Grants, 1995, 1996, 1997, 1998, 2000, and 2001.

Consultancies, Entrepreneurship, and Student Research Teams
Since 1995 I have directed over 200 student projects focused on marketing plans, business plans, and retail marketing plans. As VIEW director (the University of Idaho's campus wide entrepreneurship program) I have worked closely with student teams and researchers from across campus to develop business plans focused on commercialization. Along with Steve Shook (Professor of Marketing) and Ken Cain (Associate Professor of Fish and Wildlife Resources) and the Office of Technology Transfer I have mentored the student team working on the Fish Probiotic business plan since January 2010. Combined with my formal education in business I have eight years of successful experience in the commercial sector.

OTHER SECTOR RESOURCE COMMITMENTS:

CLEAR SPRINGS FOODS®

CLEAR SPRINGS FOODS, INC.
General Office P.O. Box 712, Buhl, Idaho 83316
Phone 208 543-4316
Sales 800 635-8211
Fax 208 543-5608
www.clearsprings.com

November 3, 2010

Letter of Support

Dr. Ken Cain
Dept. of Fish and Wildlife
University of Idaho
Moscow, ID 83844-1136

Dear Ken:

I would like to express our enthusiastic support for your proposal to the State Board of Education Incubation Fund Program titled "**Commercializing specific probiotic bacterial strains to improve fish health and reduce disease related mortality at aquaculture facilities.**" The potential to develop specific bacterial strains identified in your lab for use in aquaculture is high. Results from your lab and additional field trials showing the health benefits and reduced mortality in fish are exciting and demonstrate the potential to use these products as feed additives. As you know we have also been able to conduct a number of trials with your C6-6 strain and have observed distinct health benefits by delivering these bacteria to fish via our novel mass delivery system. We see this as another possible strategy for applying these products to fish and are very interested in establishing collaborations/partnerships with the University of Idaho in the future to push forward these products in any way that improves health management for aquaculture facilities. The needs identified in your proposal are essential to move these products into the marketplace and there is great demand for such products for aquaculture. As you know the state of Idaho is responsible for 80% of the rainbow trout produced as a food fish in the United States. Successful funding of this proposal will not only be of great interest to Clear Springs Foods, the worlds largest producer of freshwater rainbow trout, but the entire rainbow trout industry along with potentially all entities involved in public and private salmonid aquaculture.

Sincerely,

Scott

Scott E. LaPatra, Ph.D.
Director of Research and Farm Services

JON M. HUNTSMAN, JR.
Governor
GARY R. HERBERT
Lieutenant Governor

State of Utah
DEPARTMENT OF NATURAL RESOURCES
MICHAEL R. STYLER
Executive Director
Division of Wildlife Resources
JAMES F. KARPOWITZ
Division Director

November 1, 2010

Dr. Ken Cain
Department of Fish and Wildlife and
the Aquaculture Research Institute
University of Idaho
PO Box 441136
Moscow, ID 83844-1136

Dear Ken:

I am writing to confirm that the Utah Division of Wildlife Resources is very interested in collaborating with you to further investigate microbial feed additives as described in your proposal entitled "Commercializing specific probiotic bacterial strains to improve fish health and reduce disease related mortality at aquaculture facilities". As you know we are very excited about the results observed in our initial field trials with strain (C6-6) and would agree to expand this field testing to include this strain and the additional strain (C6-8) recently identified in your laboratory. Our interest is in evaluating these additives alone and in combination as a means of promoting general health and disease resistance in fish. The reduction in disease related mortality we observed in field trials with C6-6 is exciting and we would like to see such specific probiotic products commercialized and available for aquaculture.

It is our expectation that we would collaborate directly with you to test C6-6 and C6-8 both alone and in combination and at a range of dosages. We will share all data with you as you move forward to commercialize such products. We look forward to our continued collaboration and partnership.

Sincerely,
J. Christopher Wilson D.V.M.

Dr. Chris Wilson
Fisheries Experiment Station
Utah Division of Wildlife Resources

Fisheries Experiment Station, 1465 West 200 North, Logan UT 84321-6262
telephone (435) 752-1066 • facsimile (435) 752-6977 • *www.wildlife.utah.gov/fes*

UTAH DNR WILDLIFE RESOURCES

Global Medical Instrumentation, Inc.

6511 Bunker Lake Blvd
Ramsey, MN 55303

Phone: 763-712-8717
Fax: 763-712-8724
Web: www.gmi-inc.com

SALES QUOTE

Quote 0022849
Customer University of Idaho
Date 11/9/2010

Analytical Lab Instrumentation, Biotechnology Lab Instrumentation, Clinical Lab Instrumentation, General Lab Instrumentation, Medical Instrumentation

Quoted To
University of Idaho
Attn: Accounts Payable
P.O. Box 444244
Moscow, ID 83844-4244

Bill To and Ship To
University of Idaho
Dept. MMBB
LSS 142
Moscow, ID 83844-3052

REP	TERMS	FOB	CUSTOMER CONTACT INFORMATION		
SDW	Net 15	Destination	Ken Cain	kcain@uidaho.edu	208-885-7608

Product	Description	Ordered	Price	Amount
MS-F-D-10	10L Single wall vessel + heating blanket + controller + standard accessories	1.00 Ea	20,442.86 Ea	$20,442.86

NOTE:
* This is the older style of fermentation system and will not be manufactured after December 2010.
* Subject to availability.
* This system is fully supportable.
* The manufacturers warranty is valid.

new	All items quoted are brand new in original manufacturer's packaging.	1.00 Ea		
MfrWarr	Instrumentation is NEW and is covered by original manufacturer warranty.	1.00 Ea		
InstallBiotech	On-site Installation and Training	1.00 Ea	3,000.00 Ea	$3,000.00
PrepaySH	Prepay and Add Shipping/Packaging will be added to the order	1.00 Ea		

As an authorized agent for your company, please sign below to accept Quote and GMI's Terms and Conditions

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Sub-total	$23,442.86
Total	$23,442.86

CURRICULUM VITAE

University of Idaho

NAME: Cain, Kenneth D.

DATE: November 8, 2010

RANK OR TITLE: Associate Professor, Department of Fish and Wildlife (Aquaculture and Fish Health)
Associate Director, Aquaculture Research Institute (Campus Facilities)

DEPARTMENT: Fish and Wildlife Resources

OFFICE LOCATION AND CAMPUS ZIP: 105D, 1136

OFFICE PHONE: (208) 885-7608
FAX: (208) 885-9080
EMAIL: kcain@uidaho.edu

DATE OF FIRST EMPLOYMENT AT UI: November 29, 1999

DATE OF TENURE: July 1, 2005

DATE OF PRESENT RANK OR TITLE: July 1, 2005

EDUCATION BEYOND HIGH SCHOOL:

Degrees:

Ph.D., Washington State University, Pullman, Washington, 1997, Animal Sciences (Fish Immunology)
M.S., Michigan State University, East Lansing, Michigan, 1993, Fish and Wildlife (Fish Nutrition)
B.S., Michigan State University, East Lansing, Michigan, 1990, Fish and Wildlife

EXPERIENCE:

Teaching, Extension and Research Appointments:

2005 – Present, Associate Professor (Aquaculture and Fish Health), University of Idaho
2002 - Present, Associate Director, Aquaculture Research Institute, University of Idaho
1999-2005, Assistant Professor (Aquaculture and Fish Health), Fish and Wildlife Resources, University of Idaho
1998-99, Research Scientist (Postdoctoral Research Fellow), University of Technology, Sydney, Australia
1994-97, Graduate Research/Teaching Assistant, Animal Sciences Department, Washington State University
1991-93, Graduate Research Assistant, Department of Fish and Wildlife, Michigan State University

Academic Administrative Appointment:

2002-present, Associate Director (Aquaculture Research Institute), Campus facilities, University of Idaho

Non-Academic Employment including Armed Forces:

1993-94, Fish Health Technician/Fish Culturist, Clear Springs Foods, Inc., Buhl, Idaho
1989-90, Fish Culturist, Bay Port Aquaculture Systems, Inc., West Olive, Michigan
1988, Biologist's Aide, Idaho Department of Fish and Game, McCall, Idaho

Areas of Specialization:

Aquaculture vaccine development
Fish Health/Diseases
Fish Immunology/Pathology
Molecular diagnostics

Proteomics
Aquaculture development (new species)

TEACHING ACCOMPLISHMENTS:

Courses Taught (UI courses in bold):

Hatchery/Wild Fish Interactions, Fish 504, Fall 2010 (Co-teach with Dr. Dennis Scarnecchia)
Biosecurity workshop, shortcourse/workshop presented to Idaho trout industry, Hagerman, Idaho, Summer 2009
Salmon Disease Workshop, Corvalis, OR, July, 2009 (Participating instructor): Intensive 2 wk disease course for fish health professionals
Current and Emerging Pathogens of Fishes in the Pacific Northwest (Workshop presented at annual Idaho Chapter AFS meeting), Boise, ID. Feb. 2007
Coldwater Disease Workshop, Annual extension shortcourse/workshop presented to Idaho trout industry, Hagerman, Idaho, Summer 2004, 2005
Fish Disease/Health Management, Annual extension shortcourse presented to Idaho trout industry, Hagerman, Idaho, September 2000, August 2001, August 2002

Aquaculture and Fish Health, Fish 419, Spring 2000
Fish Health Management, Fish 424, Spring semesters
Concepts in Aquaculture, Fish 422, Fall semesters through 2007; Spring semesters 2007-present
Current Topics in Fish Health, Fish 494, Fall alt/yrs
Fish Disease Diagnostics and Control, Fish 524, Fall alt/yrs
Sustainable Aquaculture, Fish 504, Fall 2004 (Co-taught with Dr. Christine Moffitt)
Directed studies, Fish 499, Spring/Fall semesters as appropriate
Guest presentations annually in **Fish 102**
Served as poster judge and participate in course projects annually for the CNR college capstone course "**NR 470**"

Students Advised:

Undergraduate Students:
Approximately 30 to completion
Advised during the 2009-2010 academic year: 12 major/program advisees, interacted with 10-25 on-campus students, interacted with 10 or more former students.
Advised during the 2008-2009 academic year: 12 major/program advisees, interacted with 10-25 on-campus students, interacted with 10 or more former students.
Advised during the 2007-2008 academic year: 15 major/program advisees, interacted with 10-25 on-campus students, interacted with 10 or more former students.
Advised during the 2006-2007 academic year: 20 major/program advisees, interacted with 10-25 on-campus students, interacted with 10-25 off-campus students.
Advised during the 2005-2006 academic year: 10 major/program advisees, interacted with 10-25 on-campus students, interacted with 10-25 off-campus students.

Aquaculture Club. (2000-present) – Faculty advisor

Numerous directed study (DS: 299 or 499) students advised

Undergraduate Research Mentor:

David Burbank, McNair Scholarship, 2008

Graduate Students advised to completion of degree-major professor:

Neil Ashton, M.S., in progress

Tyson Feringher, M.S., in progress
David Burbank, M.S., in progress
Tarah Johnson, M.S., in progress
Amy Long, Ph.D., in progress
James Barron, M.S., in progress
Mark Polinski, M.S., 2009
Ben LaFrentz, Ph.D., 2007
Nicole Lindstrom, M.S., 2007
John Drennan, Ph.D., 2006
Christine Swan, M.S., 2006
Nathan Jensen, M.S., 2006
Leslie Grabowski, M.S., 2004
Wade Cavender, M.S., 2003
Ben LaFrentz, M.S., 2002

Served on graduate committee:

Carla Schubiger, (WSU vet med), in progress
Andreas Brezas, (Animal and Vet Sciences), Ph.D., in progress
Karol Gliniewicz, Ph.D., (WSU vet med), in progress
Tom Loch, Ph.D., (Michigan State University), in progress
Patricia Dowell, (Animal and Vet Sciences), M.S., in progress
Alejandro Villasante, (Animal and Vet Sciences), Ph.D., in progress
Scott Snyder (Animal and Vet Sciences), Ph.D., in progress
Catherine A. Patricolo (WSU), M.S., in progress
Heidi Henuguin (Biology), M.S., 2009
Derek Fryer, M.S., 2008
John Cheng (WSU), M.S., 2008
Shannon Amberg (CSS), Ph.D., 2008
Shannon Miller, M.S., 2007
Ryan Mann, M.S., 2007
Dustene Cummings, M.S., 2007
Johnathan Stodard (Biology), M.S., 2005
Luis Mazuera, M.S., 2005
Peggy Simpson, Ph.D., 2003
Darin Jones, M.S., 2002
Joel Green, Ph.D., 2001
Brian Peterson, Ph.D., 2001
Bill Johnson, M.S., 2000
Cameron Heuser, M.S. 2000
Tim Welker, Ph.D., 2000

Postdoctoral Researchers:

Karen Plant, 2006-present
Sudheesh Ponnerassey, 2003-2008
Tanuja Upadhyaya, 2006

Research Technicians:

Nate Jensen, 2006-present
Najeeb Parvez, 2008-present

Materials Developed:

Biosecurity workshop (notebook/manual and CD), 2009

Current and Emerging Pathogens of Fishes in the Pacific Northwest (notebook/manual and CD), 2007
Coldwater disease extension bulletin (published through Western Regional Aquaculture Center), 2004
Manual for Coldwater disease workshop, 2004
Manual for Fish Health shortcourse, 2000, 2001
Website development for Fish 422 and 424, Fall 2003 (www.cnr.uidaho.edu/fish422and424/)

Courses Developed:

Concepts in Aquaculture, Fish 422, Fall 2001
Fish Health Management, Fish 424, Spring 2001
Current Topics in Fish Health, Fish 404/504 (now 494), Fall 2001
Sustainable Aquaculture, Fish 504, Fall 2004 (Co-taught with Dr. Chris Moffitt)
Fish Disease Diagnostics and Control, Fish 524, Fall alt/yrs

Developed and implemented an Aquaculture Minor for undergraduate students, 2006

Non-credit Classes, Workshops, Seminars, Invited Lectures, etc.:

University Core course **CORS 224**, Guest lecture, May 2010
Salmon Disease Workshop, Corvalis, OR, July, 2009 (Participating instructor): Intensive 2 wk disease course for fish health professionals
Biosecurity workshop, (instructor), August 14, 2009, Hagerman, ID
Nucleospora Workshop, (participant), August 19, 2009, Boise, ID
Current and Emerging Pathogens of Fishes in the Pacific Northwest, (instructor) February 20, 2007, Idaho Chapter AFS, continuing education (one day workshop)
CNR Outreach Workshop (invited participant/contributor), July 12, 2007
Northwest Reproductive Sciences Symposium (Invited speaker) Reproductive aspects associated with the development of a conservation aquaculture program for burbot (*Lota lota maculosa*), March 23, 2007
Lower Snake River Compensation Plan Office Annual Meeting (Invited Presenter), March 12-16, 2007
Palouse Unit AFS meeting (Invited Seminar) Research overview, November 28, 2007
Flavobacterium 2007 workshop (Invited participant/organizer), International meeting bringing over 80 researchers together from all over the world, May 2-4, 2007
Fish Immunology Workshop, (invited workshop/seminar), Oct 5, 2006, Benchmark Biolabs, Lincoln, NE
Coldwater Disease Workshop, Annual extension shortcourse presented to Idaho trout industry, Hagerman, Idaho, June 10, 2004, June 2005, August 2005
Aquaculture short course for Native Americans, (invited instructor) June 15-July 23, 2004, Hagerman, Idaho
WSU Vancouver (invited seminar), WSU Seminar Series, October 4, 2004
46th Western Fish Disease Workshop, (organizer, speaker and session chair) AFS/Fish Health Section, June 27-29, Boise, ID. 2005.
Coldwater disease workgroup meeting, (invited participation with Federal, State, and Tribal agencies to address coldwater disease problems), Seattle, Washington, February 5, 2004
Workshop for the Center for Reproductive Biology, (invited seminar) Stimulating protective immunity in rainbow trout to the fish pathogen *Flavobacterium psychrophilum*, Washington State University, Pullman, Washington, June 11, 2003
Fish Disease/Health Management workshop/shortcourse, Annual extension shortcourse presented to Idaho trout industry, Hagerman, Idaho, September 2000, August 2001, August 2002
Fish Immunology Workshop, Annual American Fisheries Society/Fish Health Section meeting, Gig Harbor, Washington, June 2000
Oregon State University, Fish Disease Laboratory (invited seminar), March 2001
FISH 102 (invited presentation), September 2000
8th Congress of the International Society of Developmental and Comparative Immunology (invited presentation) Cairns, Australia, July 2000
Idaho Aquaculture Association, annual meeting (invited presentation) June 2000
FISH 501 (invited presentation) April 2000

SCHOLARSHIP ACCOMPLISHMENTS:

Publications:

Refereed:

Plant, K.P., LaPatra, S.E., Call, D.R., and Cain, K.D. Immunization of rainbow trout (*Oncorhynchus mykiss*) with *Flavobacterium psychrophilum* proteins elongation factor-Tu, SufB Fe-S assembly protein and ATP synthaseβ. *Journal of Fish Diseases* (Accepted)

Neufeld, M.D., Cain, K., Jensen, N., Ireland, S.C., and Paragamian, V.L. Movement of Lake Origin Burbot Reared in a Hatchery Environment and Released into a Large River. *Transactions of The American Fisheries Society* (Accepted - in revision)

Cain, K.D and Swan, C.M. 2010. Barrier Function and Immunology. "The Multifunctional Gut of Fish" Elsevier Inc., (Invited book chapter), *Fish physiology* vol: 30, 112-134.

Polinski, M.P., Drennan, J.D., Batts, W.N., Ireland, S.C., Cain, K.D. 2010. Establishment of a cell line from burbot *Lota lota* with characterization of susceptibility to IHNV, IPNV and VHSV. *Diseases of Aquatic Organisms* 90, 15-23

Polinski, M.P., Fehringer, T.R., Johnson, K.A., Snekvik, K.R., LaPatra, S.E., LaFrentz, B.R., Ireland, S.C., Cain, K.D. 2010. Characterization of susceptibility and carrier status of burbot to IHNV, IPNV, *Flavobacterium psychrophilum, Aeromonas salmonicida,* and *Renibacterium salmoninarum. Journal of Fish diseases* 33, 559-570

Polinski, M.P., Johnson, K.A., Ireland, S.C., Jensen, N.R., and Cain, K.D. 2010. Assessment of formalin and hydrogen peroxide use during egg incubation of burbot (*Lota lota maculosa*). *North American Journal of Aquaculture* 72, 111-117

LaFrentz, B.R., LaPatra, S.E., Call, D.R., Wiens, G.D., and Cain, K.D. 2009. Proteomic analysis of *Flavobacterium psychrophilum* cultured *in vivo* and in iron-limited media. *Diseases of Aquatic Organisms* 87: 171-182

Lindstrom, N.M., Call, D.R., House, M.L., Moffitt, C.M., and Cain, K.D. 2009. A quantitative enzyme-linked immunosorbent assay (ELISA) and filtration-based fluorescent antibody test (FAT) as potential tools to screen broodstock for *Flavobacterium psychrophilum* infection. *Journal of Aquatic Animal Health* 21(1): 43-56

Plant, K.P., LaPatra, S.E., and Cain, K.D. 2009. Vaccination of rainbow trout (*Oncorhynchus mykiss*) with recombinant and DNA vaccines produced to *Flavobacterium psychrophilum* heat shock proteins 60 and 70. *Journal of Fish Diseases* 32(6): 521-534

Shah, D.H., Cain, K.D., Wiens, G.D., and Call D.R. 2008. Challenges associated with heterologous expression of *Flavobacterium psychophilum* proteins in *Escherichia coli. Marine Biotechnology* 10: 719-730

Lloyd, S.J., Snekvik, K.R., St-Hilaire, S., LaPatra, S.E., Cain, K.D., and Call, D.R. 2008. Strawberry Disease lesions in rainbow trout (*Oncorhynchus mykiss*) are closely associated with a Rickettsia-like organism. *Diseases of Aquatic Organisms* 82: 111-118

LaFrentz, B.R., LaPatra, S.E., Call, D.R.., and Cain, K.D. 2008. Development and characterization of rifampicin resistant *Flavobacterium psychrophilum* strains and their potential as live attenuated vaccine candidates. *Vaccine* 26 (2008) 5582–5589

Chen, J., Davis, M.A., LaPatra, S.E., Cain, K.D., Snekvik, K.R., and Call, D.R. 2008. Genetic

diversity of *Flavobacterium psychrophilum* recovered from commercially raised rainbow trout *Oncorhynchus mykiss* (Walbaum) and spawning Coho salmon *Oncorhynchus kisucth. Journal of Fish Diseases* 31: 765-773

Dodson, M.V., Kinkel, A., Vierck, J.L., Cain, K.D., Wick, M.P., and Ottobre, J.S. 2008. Unidentified cells reside in fish skeletal muscle. *Cytotechnology* 56: 171-178

Swan, C. M., Lindstrom, N. M., Cain, K. D. 2008. Identification of a localized mucosal immune response in rainbow trout *Oncorhynchus mykiss* following immunization with a protein-hapten antigen. *Journal of Fish Diseases* 31, 383-393

Jensen, N. R., Williams, S. R., Ireland, S. C., Siple, J. T., Cain, K.D. 2008. Evaluation of egg incubation methods and larval feeding regimes for North American burbot. *North American Journal of Aquaculture* 70, 162-170

Jensen, N. R., Zuccarelli , M. D., Patton, S. J., Williams, S. R., Ireland, S. C., Cain, K. D. 2008. Cryopreservation and methanol effects on sperm motility and egg fertilization rates for North American burbot semen. *North American Journal of Aquaculture* 70, 38-42

Sudheesh, P.S., Crane, S., Cain, K.D. and Strom, M.S. 2007. Sortase inhibitor phenyl vinyl sulfone inhibits *Renibacterium salmoninarum* adherence and invasion of host cells. *Diseases of Aquatic Organisms* 78, 115-127

Cain, K.D., and LaFrentz, B.R. 2007. Laboratory Maintenance of *Flavobacterium psychrophilum* and *Flavobacterium columnare. Current Protocols in Microbiology* (Book Chapter) 6:13B.1.1-13B.1.12

LaFrentz, B. R., Lindstrom, N. M., LaPatra, S. E., Call, D. R., and Cain, K. D. 2007. Electrophoretic and Western blot analyses of the lipopolysaccharide and glycocalyx of *Flavobacterium psychrophilum. Fish and Shellfish Immunology* 23, 770-780

Drennan, J. D., LaPatra, S. E., Swan, C. M., Ireland, S., and Cain, K. D. 2007. Characterization of serum and mucosal antibody responses in white sturgeon (*Acipenser transmontanus* Richardson) following immunization with WSIV and a protein hapten antigen. *Fish and Shellfish Immunology* 23, 657-669

Drennan, J. D., LaPatra, S. E., Samson, C. A., Ireland, S., Eversman, K. F., and Cain, K. D. 2007. Evaluation of lethal and non-lethal sampling methods for the detection of WSIV infection in white sturgeon *Acipenser transmontanus* Richardson. *Journal of Fish Diseases* 29, 1-13

Ramsrud, A., LaFrentz, S. A., LaFrentz, B. R., Cain, K. D., and Call, D. R. 2007. Differentiating 16S rRNA alleles of *Flavobacterium psychrophilum* using a simple PCR assay. *Journal of Fish Diseases*, 30, 175-180

Sudheesh, P. S., LaFrentz, B. R., Call, D. R., Seims, W. F., LaPatra, S. E., Wiens, G. D., and Cain, K. D. 2007. Identification of potential vaccine target antigens by immunoproteomic analysis of a virulent and a non-virulent strain of the fish pathogen *Flavobacterium psychrophilum. Diseases of Aquatic Organisms,* 74, 37-47

Drennan, J. D., LaPatra, S. E., Siple, J. T., Ireland, S., and Cain, K. D. 2006. Transmission of white sturgeon iridovirus in Kootenai River white sturgeon (Acipenser *transmontanus*). *Diseases of Aquatic Organisms,* 70. 37-45

Soule, M., LaFrentz, S., Cain, K., LaPatra, S., and Call, D.R. 2005. Polymorphisms in 16s rRNA genes of *Flavobacterium psychrophilum* correlate with elastin hydrolysis and tetracycline resistance. *Diseases of Aquatic Organisms* 65, 209-216.

Soule, M., Cain, K., LaFrentz, S., and Call, D.R. 2005. Combining suppression hybridization and microarrays to map the intra-specific phylogeny of *Flavobacterium psychrophilum. Infection and Immunity* 73(6), 3799-3802.

Drennan, J.D., Ireland, S., LaPatra, S.E., Grabowski, L., Carrothers, T. and K.D. Cain. 2005. High density rearing of white sturgeon (*Acipenser transmontanus*) induces white sturgeon iridovirus disease among asymptomatic carriers. *Aquaculture Research* 36, 824-827.

Biga, P.R., Peterson, B.C., Schelling, G.T., Hardy, R.W., Cain, K.D., Overturf, K, and T.L. Ott. 2004. Serum somatotropin, insulin-like growth factor-I, and antibody production in rainbow trout (*Oncorhynchus mykiss*) treated with sustained-release bovine somatotropin (rbST). Aquaculture 246, 437-445.

Grabowski, L.D., LaPatra, S.E., and Cain, K.D. 2004. Systemic and mucosal antibody response in tilapia (*Oreochromis niloticus,* L.) following immunization with *Flavobacterium columnare. Journal of Fish Diseases* 27, 573-581.

Cavender, W.P., Wood, J.S., Powell, M.S., Overturf, K., and Cain, K.D. 2004. Real-time quantitative PCR (QPCR) to identify *Myxobolus cerebralis* in rainbow trout (*Oncorhynchus mykiss). Diseases of Aquatic Organisms* 60, 205-213.

Biga, P.R., Cain, K.D., Hardy, R.W., Shelling, G.T., Overturf, K., Roberts, S.B., Goetz, F.W., and Ott, T.L. 2004. Growth hormone differentially regulates muscle myostatin 1 and –2 and increases circulating cortisol in rainbow trout (*Oncorhynchus mykiss). General and Comparative Endocrinology* 138, 32-41.

LaFrentz, B.R., LaPatra, S.E., Jones, G.R., and Cain, K.D. 2004. Protective immunity in rainbow trout *Oncorhynchus mykiss* following immunization with distinct molecular mass fractions isolated from *Flavobacterium psychrophilum. Diseases of Aquatic Organisms* 59, 17-26.

Biga, P.R., Schelling, G.T., Hardy, R.W. Cain, K.D., Overturf, K. and Ott, T.L. 2004. The effects of recombinant bovine somatotropin (rbST) on tissue IGF-1, IGF-1 receptor, and GH mRNA levels in rainbow trout (*Oncorhynchus mykiss*). *General and Comparative Endocrinology* 135(3), 324-333.

Cavender, W.P., Johnson, K.A., and Cain, K.D. 2003. Distribution of *Myxobolus cerebralis* within a free-flowing river system during the migration period for juvenile anadromous salmonids in Idaho. *Journal of Aquatic Animal Health* 15(2), 158-166.

Cain, K.D., Grabowski, L. and Reilly, J.J. 2003. Immunomodulatory effects of ∃-1,3, glucan administered to tilapia (*Oreochromis nilotocus*) in a Spirulina based diet, *Aquaculture Research 34*, 1241-1244.

Peterson, B.C., Simpson, P.R., Cain, K.D., Hardy, R.H., Schelling, G.T. and Ott, T.L. 2003. Administration of somatistatin-14 and immunoneutralization of somatostatin in rainbow trout (*Oncorhynchus mykiss*), *Journal of Fish Biology* 63, 506-522.

LaFrentz, B.R., LaPatra, S.E., Jones, G.R. and Cain, K.D. 2003. Passive immunization of rainbow trout (*Oncorhynchus mykiss*) to *Flavobacterium psychrophilum*, the causative agent of coldwater disease and rainbow trout fry syndrome. *Journal of Fish Diseases* 26, 377-384.

LaFrentz, B.R., LaPatra, S.E., Jones, G.R., Congleton, J.L., Sun, B. and Cain, K.D. 2002. Characterization of serum and mucosal antibody responses and relative percent survival in rainbow trout (*Oncorhynchus mykiss*) following immunization and challenge with *Flavobacterium psychrophilum. Journal of Fish Diseases*. 25, 703-713.

Cain, K.D., Jones, D.R. and Raison, R.L. 2002. Antibody-antigen kinetics following immunization of

rainbow trout (*Oncorhynchus mykiss*) with a T-cell dependent antigen. *Developmental and Comparative Immunology:* 26 181-190.

Cain, K.D., Jones, D.R. and Raison, R.L. 2000. Characterization of mucosal and systemic immune responses in rainbow trout (*Oncorhynchus mykiss*) using surface plasmon resonance. *Fish and Shellfish Immunology:* 10(8) 651-666.

Cain, K.D., Byrne, K.M., Brassfield, A.L., LaPatra, S.E. and Ristow, S.S. 1999. Temperature dependent characteristics of a recombinant infectious hematopoietic necrosis virus glycoprotein produced in insect cells. *Diseases of Aquatic Organisms* 36 1-10.

Cain, K.D., LaPatra, S.E., Shewmaker, B., Jones, J., Byrne, K.M. and Ristow, S.S. 1999. Immunogenicity of a recombinant infectious hematopoietic necrosis virus glycoprotein produced in insect cells. *Diseases of Aquatic Organisms* 36 67-72.

Cain, K.D., LaPatra, S.E., Baldwin, T.J., Shewmaker, W.D., Jones, J.R. and Ristow, S.S. 1996. Characterization of mucosal immunity in rainbow trout (*Oncorhynchus mykiss*) challenged with infectious hematopoietic necrosis virus (IHNV): identification of antiviral activity. *Diseases of Aquatic Organisms* 27 (3): 161-172.

Cain, K.D. and Garling, D. 1995. Pretreatment of soybean meal with phytase for salmonid diets to reduce phosphorus concentrations in hatchery effluents. *Prog. Fish Cult.* 57: 114-119.

Peer Reviewed/Evaluated:

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LaFrentz, B.R., LaPatra, S.E., Jones, G.R., Congleton, J.L., Sun, B. and Cain, K.D. 2002. Characterization of serum and mucosal antibody responses and relative percent survival in rainbow trout (*Oncorhynchus mykiss*) following immunization and challenge with *Flavobacterium psychrophilum*. 4th International Symposium on Aquatic Animal Health, New Orleans, Louisiana, September 1-5.

Cain, K.D., LaFrentz, B.R., Grabowski, L.G., and LaPatra, S.E. 2002. Antigenic and immunogenic properties of *Flavobacterium psychrophilum*. 4th International Symposium on Aquatic Animal Health, New Orleans, Louisiana, September 1-5.

LaFrentz, B.R., LaPatra, S.E., Jones, G.R., and Cain, K.D. 2002. Passive immunization of rainbow trout *(Oncorhynchus mykiss)* against *Flavobacterium psychrophilum*. 4th International Symposium on Aquatic Animal Health, New Orleans, Louisiana, September 1-5.

Drennan, J.D., Ireland, S., Siple, J., LaPatra, S., and Cain, K.D. 2002. Investigating the role of vertical transmission of WSIV and characterizing mechanisms of viral immunity in White Sturgeon (*Acipenser transmontanus*). Columbia River Basin White Sturgeon Symposium, Vancouver, Washington, August 12-14.

LaPatra, S.E., LaFrentz, B.R., Jones, G.R., Morton, A.W., Higgins, M., and Cain, K.D. 2002. Susceptibility of passively immunized rainbow trout and challenge survivors to *Flavobacterium psychrophilum*, 43rd AFS/Western Fish Disease Workshop, Corvallis, Oregon, June 25-26.

Cain, K.D., LaFrentz, B.R., Jones, G.R., and LaPatra, S.E. 2002. Passive immunization of rainbow trout against *Flavobacterium psychrophilum*. 43rd AFS/Western Fish Disease Workshop, Corvallis, Oregon, June 25-26.

Cain, K.D. 2002. Fish Vaccine development: Implications for Improved Reproductive Efficiency. Center for Reproductive Biology 6th Annual Retreat, Camp Larson – Coeur d'Alene Lake, Idaho, June 13-14 (invited presentation)

LaFrentz, B.R., LaPatra, S.E., Jones, G.R., Congleton, J.L., Sun, B., and Cain, K.D. 2002. Characterization of serum and mucosal antibody responses and relative percent survival in rainbow trout (*Oncorhynchus mykiss*) following immunization and challenge with *Flavobacterium psychrophilum*. Idaho Aquaculture Association annual meetings, Twin Falls, Idaho, June 8 (invited presentation)

Cain, K.D. 2002. Broodstock immunization: A potential strategy to reduce disease related mortality in ESA listed stocks. Salmon Recovery Symposium: Issues on Pacific Salmon Recovery in the Northwest: Reproduction and Conservation, Moscow, Idaho, March 28-29 (invited presentation)

Cavender, W.P., Johnson, K.A., and Cain, K.D. 2002. Distribution of *Myxobolus cerebralis* during the migration period for juvenile anadromous salmonids in the Snake and Salmon rivers of Idaho. 8th Annual Whirling Disease Symposium, Denver, Colorado, February 13-15.

Cain, K.D. 2002. Pathology and disease dispersal in supplemented systems: Identification of disease-related risks. Tribal supplementation workshop. Moscow, Idaho, January 24-

25(invited presentation)

Cain, K.D. 2001. Broodstock vaccination strategies for enhanced reproductive efficiency through disease resistance, Center for Reproductive Biology (WSU/UI): Salmon Recovery Program & National Marine Fisheries Service Meeting, Spokane, Washington, November 13 (invited presentation)

Cain, K.D., Grabowski, L., and LaPatra, S.E. 2001. Separation and comparison of proteins from virulent and nonvirulent strains of the fish pathogen *Flavobacterium psychrophilum*, AFS/Fish Health Section meetings, Victoria, B.C. Canada.

LaFrentz, B.R., Grabowski, L., LaPatra, S.E., and Cain, K.D. 2001. Characterization of serum and mucosal antibody responses to *Flavobacterium psychrophilum*: Is antibody important for protection? AFS/Fish Health Section meetings, Victoria, B.C. Canada.

LaPatra, S.E., Shewmaker, W., Jones, G., Cain, K., and Overturf, K. 2001. Understanding aquatic animal virus survival and its role in risk assessment. AFS/Fish Health Section meetings, Victoria, B.C. Canada.

Cain, K.D., Mucosal and Systemic Immunity in Fish. Oregon State University's Fish Disease Laboratory Seminar series, Corvallis, Oregon. March 2001 (invited presentation)

Cain, K.D. 2000. Immune responses in fish: What affects resistance to disease? Idaho Aquaculture Association annual meetings, Twin Falls, Idaho (invited presentation)

Cain, K.D., Jones, D.R. and Raison, R.L., 2000. Antibody-antigen kinetics following immunization of rainbow trout (*Oncorhynchus mykiss*) with a T-cell dependent antigen. 8th Congress of the International Society of Developmental and Comparative Immunology, Cairns, Australia (invited presentation)

Prasad, S.S., Cain, K.D., Jones, D.R. and Raison, R.L. 1999. Identification of cell surface proteins using 2-D gel electrophoresis. *Conference proceedings* Royal North Shore Hospital/ University of Technology, Sydney, Australia.

Patents:

Cain, K.D., LaFrentz, B.R., and LaPatra, S.E. "Vaccines for Diseases of Fish," issued on June 22, 2010 as US Patent No. 7,740,864

Cain, K.D. An antibody for screening salmon and trout broodstock for the aquatic pathogen *Flavobacterium psychrophilum*, which causes bacterial coldwater disease and rainbow trout fry syndrome. Technology licensed to ImmunoPrecise Antibodies, Ltd. (2009)

Cain, K.D., Probiotic bacterial strain C6-6 (*Enterobacter sp.*) for use in fish disease control. Invention disclosure (OTT case number 09-002; filed: 2009)

Cain, K.D., LaFrentz, B.R., and LaPatra, S.E. Vaccines for diseases of fish. Non-provisional patent filed 6/2/08; patent application number 12/156,509

Cain, K.D., LaFrentz, B.R., and LaPatra, S.E. Development of a rifampicin resistant strain of *Flavobacterium psychrophilum* for use as a live attenuated vaccine for the prevention of bacterial coldwater disease and rainbow trout fry syndrome, (Provisional patent application filed on 6/22/2007, application number 60/936,756).

Cain, K.D., Call, D., and Lindstrom, N. Development of a quantitative ELISA to detect *Flavobacterium psychrophilum*, Invention Disclosure, (Filed: February 2007).

Cain, K.D. and Cavender, W. QPCR diagnostic probe for detecting the whirling disease parasite in fish: Real-time quantitative polymerase chain reaction (QPCR) technique composed of a forward and reverse primer and a TazMan® Minor Groove Binding (MGB) probe specific for the genetic sequence that encodes the Heat shock protein 70 (Hsp 70) gene of *Myxobolus cerebralis*. Invention Disclosure, (Filed: October 2003).

Grants and Contracts Awarded:

Funded:

Cain, Kenneth (Principal), "Pilot testing of potential phyto-therapeutics for inhibition of bacterial pathogens important to aquaculture", Research service agreement, Private company (Liveleaf Biosciences), **$5,489** (October 2010 – April 2011)

Cain, Kenneth (Principal), "Development of Burbot (*Lota lota*) conservation aquaculture and evaluation of disease susceptibility", Sponsored by the Kootenai Tribe of Idaho (BPA), Federal, **$161,741** (January 2010 – January 2011)

Gilman, Vladimir (Prinicpal) Cain, Kenneth (Co-Principal)Development of a High Sensitivity and Specificity Quantitative Aptamer Assay for Coldwater Disease Management Applications. Sponsored by Infoscitex Corporation as a USDA/SBIR phase I subcontract, Federal, $100,000 **($27,000 UI),** (July 2010 – Jan 2011)

Cain, Kenneth D (Principal), "Comparative genomics and proteomics of *Flavobacterium psychrophilum*: moving toward vaccine development", Sponsored by WSU/UI Aquaculture Initiative (USDA/CSREES), Federal, $96,000 (**$43,000 UI**). (October 2010 - October 2011).

Hardy, Ron (Principal); Cain, Kenneth (Co-Principal), "Converting Alaska fish byproducts into value added ingredients and products" Sponsored by USDA, ARS (University of Alaska), Federal, **$234,956** (September 2009 – September 2010)

Cain, Kenneth D (Principal), "Comparative genomics and proteomics of *Flavobacterium psychrophilum*: moving toward vaccine development", Sponsored by WSU/UI Aquaculture Initiative (USDA/CSREES), Federal, $100000 (**$50,000 UI**). (October 2009 - October 2010).

Cain, Kenneth D (Principal), "Development of autochthonous probiotics to control fish diseases in aquaculture", Sponsored by WSU/UI Aquaculture Initiative (USDA/CSREES), Federal, **$30,000** (October 2009 - October 2010).

Cain, Kenneth (Principal); Plant, Karen (Co-Principal), "Understanding innate defense mechanisms to enhance control strategies for infectious hematopoietic necrosis virus in rainbow trout." Sponsored by WSU/UI Aquaculture Initiative (USDA/CSREES), Federal, **28,000** (October 2009 - October 2010)

Hardy, McIver, Cain, Murdock, Powell, Rodnick. Transforming environmental and physiological assessments using fish erythrocyte gene expression to measure responses. *National Science Foundation.* **$600,000** (12/09-12/11).

Cain, Kenneth (Principal), "Development of Burbot (*Lota lota*) conservation aquaculture and evaluation of disease susceptibility", Sponsored by the Kootenai Tribe of Idaho (BPA), Federal, **$154,151** (November 2008 – January 2010)

Cain, Kenneth D (Principal), "Comparative genomics and proteomics of *Flavobacterium psychrophilum*: moving toward vaccine development", Sponsored by WSU/UI Aquaculture Initiative (USDA/CSREES), Federal, $100000 (**$40,000 UI**). (October 2008 - October 2009).

Cain, Kenneth D (Supporting), Douglas Call (Co-Principal - WSU), "Identifying the etiologic agent of

Strawberry Disease in rainbow trout",Sponsored by WSU/UI Aquaculture Initiative, Federal, **$25,000 UI**. (October 2008- October 2009).

Cain, Kenneth D (Principal), Douglas Call (Co-Principal - WSU), Fornshell, Gary CG (Supporting), "Coldwater disease prevention and control through vaccine development and diagnostic improvements", Sponsored by Western Regional Aquaculture Center (USDA/CSREES), Federal, **$324,874: $158,230 to UI**. (October 2007 - October 2011).

Cain, Kenneth D (Principal), "Comparative genomics and proteomics of *Flavobacterium psychrophilum*: moving toward vaccine development", Sponsored by WSU/UI Aquaculture Intiative (USDA/CSREES), Federal, **$100,000: $50,000 to UI**. (October 2007 - October 2008).

Cain, Kenneth (Principal), "Development and Evaluation of Extensive Larval and Juvenile Rearing Techniques and Systems for Burbot (*Lota Lota maculosa*) to meet Conservation Aquaculture Needs", Sponsored by USFWS, Federal, **$66,000** (October 2007 – September 2011).

Cain, Kenneth (Principal), "Development of Burbot (*Lota lota*) conservation aquaculture and evaluation of disease susceptibility", Sponsored by the Kootenai Tribe of Idaho (BPA), Federal, **$143,362** (November 2007 – November 2008)

Cain, Kenneth (Principal), Tim Alefantis (Co-Principal) "Bacterial Ghosts as a Vaccine for the Prevention of Cold Water Disease Affecting the Salmonid Aquaculture Industry", Sponsored by Vital Probes, Inc. as a USDA/SBIR phase I subcontract, Federal, **$75,000: $22,624** to UI, (July 2007 – Jan 2009)

St. Hilaire, Sophie (Principal – ISU), Cain, Kenneth (Co-investigator with many others), "The development of an oral delivery system for DNA vaccines in aquatic species", Idaho State Board of Education (SBOE) One-time grant, **$550,000: $24,150** to UI. (January 2008 – January 2010)

Strom, Mark (Principal-NOAA), Cain, Kenneth (Co-Principal), "Genomic and proteomic expression profiling of *Renibacterium salmoninarum* during the infection of Chinook salmon", NOAA Fisheries, Federal, **$90,088** (September 2007 – September 2009)

Cain, Kenneth D (Supporting), "Identifying the etiologic agent of Strawberry Disease in rainbow trout", Sponsored by WSU/UI Aquaculture Initiative, Federal, $35000. (October 2007 - October 2009).

Cain, Kenneth D (Principal), "Development of Burbot (Lota lota) conservation aquaculture and evaluation of disease susceptibility", Sponsored by Kootenai Tribe of Idaho (BPA), Federal, $126963. (December 2006 - December 2008).

Cain, Kenneth D (Principal), "Comparative genomics and proteomics of *Flavobacterium psychrophilum*: moving toward vaccine development", Sponsored by WSU/UI Aquaculture Initiative (USDA/CSREES), Federal, $100000. (October 2006 - October 2007).

Cain, Kenneth D (Principal), "Development of autochthonous probiotics to control fish diseases in aquaculture", Sponsored by WSU/UI Aquaculture Initiative (USDA/CSREES), Federal, $34987. (October 2006 - October 2009).

Cain, Kenneth D (Supporting), "Identifying the etiologic agent of Strawberry Disease in rainbow trout", Sponsored by WSI/UI Aquaculture Initiative, Federal, $35000. (October 2006 - October 2007).

Cain, Kenneth D (Co-Principal), "Control of BKD by Inactivation of the Renibacterium salmoninarum Sortase as an Alternative to Antibiotics", Sponsored by NOAA/NMFS, Federal, $79720. (September 2006 - September 2007).

Cain, Kenneth D (Principal), "ELISA detection of antibody response in fish", IDFG, $700. (September 2006 - November 2006).

Cain, Kenneth D (Co-Principal), "Genomic and proteomic expression profiling of Renibacterium salmoninarum during the infection of Chinook salmon", Sponsored by NOAA/NMFS, Federal, $24600. (May 2006 - September 2006).

PI: Dr. Ken Cain, Co-PI: Dr. Keith Johnson (IDFG), Distribution of *Mxyobolus cerebralis* during the Migration Period for Juvenile Anadromous Salmonids in the Snake and Salmon Rivers of Idaho, Whirling Disease Foundation, 9/00-12/01, $29,954.

PI: Dr. Scott LaPatra Co-PI: Dr. Ken Cain, Immunological Responses of Rainbow Trout to Coldwater Disease, USDA/SBIR phase I proposal with Clear Springs Foods, 5/01-11/01, $75,000 (subcontract: $22,212).

PI: Dr. Charles Hatch, Co-investigators: Brannon, Hardy, Powell, Cain, Overturf. Innovative Seafood Production: Customizing Feeds/Fish in Sustainable Aquaculture, NSF, 1/01-12/04, $564,709.

Support (to date) under this funding:

PI: Dr. Ken Cain, Immune response to *Flavobacterium columnare* in tilapia *(Oreochromis niloticus):* implications for an ornamental fish vaccine, approx.: $100,000.

PI: Dr. Ken Cain, Effects of Density on Manifestation of WSIV in White Sturgeon, Kootenai Tribe of Idaho, 4/01-12/01, $10,000.

PI: Dr. Ken Cain, Co-PI: Dr. Keith Johnson (IDFG), Distribution of *Mxyobolus cerebralis* during the Migration Period for Juvenile Anadromous Salmonids in the Snake and Salmon Rivers of Idaho, continued funding through LSRCP and Idaho Power, 1/01-12/01, $16,092.

PI: Dr. Ken Cain, Beneficial Use Reconnaissance Program (BURP), Idaho DEQ, 8/01- 11/01, $164,080.

Co-PI: Dr. Ken Cain, USDA/CSREES: Aquaculture Idaho and Washington: Congressional initiative in support of aquaculture research at UI and WSU: FY02 $600,000: FY03 $750,000: FY04 $650,000. Funding supports small individual and larger WSU/UI collaborative projects.

Support (to date) under this funding:

PI: Dr. Ken Cain, Mucosal Immunity in Fish: Triggering the First Line of Defense, 9/02- 9/05, FY02 $30,000: FY03 $35,000: FY04 $35,000.

PI: Dr. Ken Cain, Co-PI: Dr. Doug Call, Collaborators: Scott LaPatra, Gary Thorgaard, Ken Overturf. Comparative genomics and proteomics of *Flavobacterium psychrophilum* and regulation of host genes during a protective immune response, 9/02-9/04, FY02 $100,000{$50,000 (UI)}: FY03 $100,000 {$50,000 (UI)}: FY04 $100,000 {$50,000 (UI)}.

PI: Dr. Ken Cain, Separation and comparison of proteins from virulent and nonvirulent strains of the fish pathogen *Flavobacterium psychrophilum,* using a 2-D electrophoretic approach, Bio-Rad company, 3/01, $500.

PI: Dr. Ken Cain, (Service contract), Histology and data analysis, Clear Springs Foods, Inc., 9/00-1/01, $7,000.

PI: Dr. Ken Cain, (Service contract), Data analysis for Tilapia diet study, Hartz Mountain Corporation, 1/01-5/01, $4,500.

PI: Dr. Ken Cain, (Service contract), Analysis of fish T-cell antibodies, Immuno-Precise Antibodies Ltd., 1/02-10/02, $3,800.

PI's: Dr. Ken Cain, Dr. Douglas R. Call, Dr. Rollin Hotchkiss, Dr. Frank J. Loge, Development of a Comprehensive Monitoring Protocol to Characterize the Concentration and Associated Health Risks of Salmonid Pathogens Suspended in Water, Washington Water Resources, December 2001, $19,997.

PI's: Cain, Cloud, Nagler, Thorgaard, Ingermann, Byrne, McElwain, Passavant, Phillips, WSU/UI Center for Reproductive Biology, WSU and UI Salmon Restoration Program – "Broodstock Vaccination Strategies for Enhanced Reproductive Efficiency Through Disease Resistance" and 8 other projects, USFWS ($500,000 FY02; $375,000 FY03)

Support (to date) under this funding:

PI: Dr. Ken Cain, Reduction of disease-related impacts on important salmonid stocks through broodstock immunization against key pathogens, 7/02-10/05, $101,947.

PI: Dr. Ken Cain, Identifying and evaluating immunogenic components of the fish pathogen *Flavobacterium psychrophilum.* UI seed grant program, 7/02-10/03, $10,000.

PI: Dr. Ken Cain, A Quantitative PCR (QPCR) Approach to Rapidly Distinguish Between *Myxobolus* Species and Assess Infection Severity in Fish. Whirling Disease Foundation, 7/02-12/03, $35,167.

PI: Dr. Scott LaPatra Co-PI: Dr. Ken Cain, Immunity to *Flavobacterium psychrophilum* antigens and development of a coldwater disease (CWD) vaccine. USDA/SBIR 9/03-9/05, $299,907 (Subcontract $148,000 to UI).

PI: Dr. Ken Cain, Feasibility assessment and development of Burbot *(Lota lota)* conservation aquaculture. Kootenai Tribe of Idaho, 9/03-9/04, $46,545.

PI: Dr. Ken Cain, Primitive mechanisms of immunity in white sturgeon *(Acipenser transmontanus)* to the viral pathogen, white sturgeon iridovirs (WSIV). UI seed grant program, 7/03-7/04, $9,909.

PI: Dr. Ken Cain, Gary Fornshell, Bacterial disease workshop, UI/WSU Aquaculture Initiative Extension Products, Support for hosting annual disease workshop in Hagerman, Idaho, 04-05, $4,142.

PI: Dr. Fran Wagner, Dr. Ken Cain, Dr. George Newcombe, Dr. Armando MacDonnell, Under the microscope. USDA Equipment grant for teaching microscope, 03 $25,000.

PI: Dr. Ken Cain and John Drennan, Direct DNA amplification of the *ribonucleotide reductase* gene from white sturgeon *iridovirus.* Laboratory for Ecological and Conservation genetics – DeVlieg Small Grants Project, $683.

PIs: Dr. Lisette Waits, Dr. Steve Brunsfeld, Dr. Cort Anderson Co-PIs: Cain and others. Research Center Grant submitted to establish the Center for Research on Invasive Species and Small Populations (CRISSP). State Board of Education (SBOE), 04-07 $1,000,000.

PI: Dr. Ken Cain, Burbot *(Lota lota)* Development of Conservation Aquaculture Techniques for Burbot *(Lota lota).* Kootenai Tribe of Idaho, 9/04-9/06, $97,357: funding tentatively agreed on (start date 9/04)

PI: Dr. Ken Cain, Improved Methods to Limit Vertical Transmission of WSIV in Progeny of White Sturgeon, Kootenai Tribe of Idaho, 3/02-12/05, $126,373: ($53,209 – yr 1, $35,068 – yr 2, $38,096 – yr 3)

Submitted:

PI: Dr. Ken Cain, Development of Techniques to Culture Pacific Lamprey in the Snake River Basin. USFWS, ($89,630)

PI: Dr. Ken Cain, Understanding *Nucleospora salmonis* infections in wild and hatchery fish to develop strategies to limit transmission and spread, Lower Snake River Compensation Program/USFWS, ($70,404)

Unfunded:

Cain, Kenneth (Principal), Call, Douglas (Co-Principal – WSU), "Characterization and delivery of

Flavobacterium psychrophilum 259.93B.17, an attenuated vaccine candidate for coldwater disease" USDA/CSREES AFRI program, Federal, **$374,998** (Submitted – 3/31/09)

Cain, Kenneth (Principal), Call, Douglas (Co-Principal – WSU), "Development of vaccines for *Flavobacterium psychrophilum* through enhanced expression of recombinant protein antigens and improved delivery of an attenuated vaccine strain", Sponsored by USDA/CSREES NRI program, Federal, **$372,002** (October 2008 – October 2011)

Walsh (Principal), Cain and 5 others (Co-PIs), "Characterization of a novel fungus infecting burbot in the pacific northwest", Sponsored by Smithsonian Institution, Federal, $43,500 (March 2008 – March 2009)

Cain, Kenneth D (Supporting), "Identification and characterization of immunodominant antigens in the catfish pathogen *Flavobacterium columnare*", Sponsored by USDA/NRI, Federal, $60000. (October 2007 - October 2010).

PI: Dr. Joe Cloud Co-PIs: Cain and others. IGERT for the Impacts of Global Change on Conservation Biology: A Union of Biology and Geography, National Science Foundation (NSF), 2,000,000.

PIs: Dr. Gary Thorgaard, Dr. Chris Bayne, Dr. Ken Cain. "Dissecting a Natural Killer Cell Complex in Trout" National Institute for Health (NIH), 1,702,174.

PI: Dr. Ken Cain, Adaptation of Larval Burbot *(Lota lota)* to Commercially Available diets. UI seed grant program, February 2004, $10,000.

PI: Dr. Ken Cain, Dr. Gary Thorgaard, Dr. Chris Bayne, Dissecting a candidate natural killer complex in trout National Institute of Health (NIH), 7/04-7/08, $1,702,174.

PI: Dr. Cort Anderson, Co-PI: Dr. Ken Cain, Isolation and sequencing of the myxozoan mitochondrial genome, and validation of PCR-based diagnostic tools McIntire-Stennis, 2003, $67,200.

PI: Dr. Ken Cain; Co-PI: Dr. Doug Call, Identification and characterization of vaccine target antigens for the fish pathogen *Flavobacterium psychrophilum.* USDA/NRI Animal Health and Well-Being program, New Investigator/Standard Strengthening, January 2002, $247,640.

PI: Dr. Ken Cain, A quantitative PCR (QPCR) approach to rapidly diagnose *Myxobolus cerebralis* and assess infection severity in fish, Whirling Disease Foundation, February 2001, $43,136.

PI: Dr. Ken Cain, Aquaculture Vaccine Development: Eliciting Immunity to *Flavobacterium psychrophilum*, UI seed grant program, February 2001, $10,000.

PI: Dr. Ken Cain, Mucosal Immunity in Fish: Triggering the First Line of Defense, USDA/NRIP Animal Health and Well-Being program, New Investigator/Standard Strengthening, January 2001, $362,166.

PI: Dr. Ken Cain, Virulence-Associated proteins of *Flavobacterium psychrophilum*, USDA/NRI seed grant program, October 2000, $75,000.

PI: Dr. Sandra Ristow, Co-PI's: Dr. Ken Cain and 7 others, Developmental and Comparative Immunobiology of Finfish, Western Regional Aquaculture Consortium (WRAC), May 2000, $400,000.

PI: Dr. Ken Cain, Immunological Characterization of White Sturgeon, UI seed grant program, February 2000, $10,000.

PI: Dr. Ken Cain, Identification of Unique Cell Surface Markers on Fish Lymphocytes, Washington Sea Grant Program, January 2000, $160,000.

Honors and Awards:

Innovation Award for Technology Licensed (Cain/ImmunoPrecise Antibodies, Ltd), 2009
Best Professional Poster presentation (Idaho Chapter AFS meeting), 2009
UI Alumni Award for Excellence, 2008
Certificate of Appreciation, UI Tech Transfer, Invention disclosure, coldwater disease vaccine
Certificate of Appreciation, UI Tech Transfer, Invention disclosure, C6-6 probiotic candidate
Outstanding Alumni Award (Alumni Hall of Fame), Swartz Creek High School, 2008
Certificate of Appreciation: As faculty mentor for UI McNair Scholarship program, 2008
Certificate of Appreciation: for Burbot conservation efforts, Kootenai Valley Resource Initiative, 2005
UI Award for Excellence in Teaching (Nominated, 2005)
UI alumni award for excellence in mentoring, 2001
Outstanding graduate student award, (Department of Animal Sciences), 1997
Best paper award nomination, (Progressive Fish Culturist), 1995
Snieszko Student Travel Award, AFS (fish health section), 1995

SERVICE:

2010-present, Executive Editor, *The Journal of Aquaculture Research and Development*
2007-present, Co-Director (Aquaculture Core Laboratories), WSU/UI Center for Reproductive Biology
2005-present, Editorial Board, *Aquaculture Research*
2005-present, Editor, Aquaculture Research Institute Newsletter

Major Committee Assignments:

UI Intellectual Properties Committee, 2010-present
Chair, 2009-2010, Dismissal Hearings Committee, University of Idaho, 2007- 2010
Ted Bjorn Scholarship Committee, 2009-present
Idaho Fish Health Policy Committee, 2007-present
National Science Foundation, Marine Biotechnology and other SBIR Review Panels, 2004-present
USDA Aquaculture SBIR review panel, 2006-present
Western Regional Aquaculture Center (WRAC), Technical advisory board – Research subcommittee, 2004-present
Chair, Rankings committee, USGS, Fish Physiologist Co-op position, 2009
Promotion and Tenure committee, Department of Animal and Veterinary Sciences, 2007
Chair, Search Committee, Riparian Ecologist, Department of Fish and Wildlife, 2007-2008
Chair, 2005 – 2007 Animal Care and Use Committee, University of Idaho, served since 2001
Search Committee, Department of Fish and Wildlife, Limnologist, 2006-2007
Search Committee, College of Natural Resources, Developmental Director, 2007
Chair, Fisheries Curriculum Review Committee, 2005
Chair, 3rd year review committee, Department of Fish and Wildlife, 2007
Burbot Recovery Team, Aquaculture Subcommittee, 2004-present
Burbot Aquaculture Facility Design Team, 2007-present
Organizing committee, 46th Western Fish Disease Workshop, AFS/Fish Health Section, June 27-29, Boise, ID. 2005.
Bacteriology Subcommittee, AFS/FHS Technical standards committee, 2003-2005
EXCOM Secretary/Treasurer, Fish Health Section of AFS, 2002-2005
CNR Scientific Equipment Committee, 2004-present
White Sturgeon Recovery Team, 2002-present
Chair, Graduate student/postdoc selection committee, Center for Research on Invasive Species and Small Populations (CRISSP), 2004
Search Committee, Department of Fish and Wildlife Resources, Fish Ecologist, 2004
DeVleig Scholarship Committee, 2002
Idaho Fish Health Protection Committee, 2001-present
Promotion and Tenure committee, Biology department, October 2001
Program review committee, Department of Fish and Wildlife Resources, 2000-01
Search Committee, Department of Fish and Wildlife Resources, Riparian Ecology, 2000-01

3rd and 5th year Review Committee, Department of Fish and Wildlife Resources, 2000
Aquaculture Wet Lab Steering Committee, Department of Fish and Wildlife Resources, 2000-present
Graduate Selection Committee, Department of Animal Science, Washington State University, 1995-96

Professional and Scholarly Organizations:

European Association of Fish Pathologists
American Society for Microbiology
American Fisheries Society (Fish Health Section)
International Society of Developmental and Comparative Immunology
International Society of Aquatic Animal Epidemiology
World Aquaculture Society
Idaho Aquaculture Association
WSU/UI Center for Reproductive Biology
Member of Center for Fish Disease Research (Oregon State University)
Center for Research on Invasive Species and Small Populations (CRISSP)

Manuscripts reviewed for following journals: (only partial list)

Fisheries
Vaccine
Microbiology
Journal of Aquatic Animal Health
North American Journal of Fish Management
Transactions of the American Fisheries Society
Aquaculture Research (Editorial board member)
Archives in Virology
Journal of Veterinary Medicine
Diseases of Aquatic Organisms
Fish and Shellfish Immunology
Journal of Fish Diseases
Journal of the World Aquaculture Society
Journal of Fish Biology

Grant proposals reviewed for the following funding agencies: (only partial list)

Maryland Sea Grant
National Research Council (Canada)
Canadian Foundation for Innovation (CFI)
National Science Foundation
USDA
Western Regional Aquaculture Center
Great Lakes Trust Foundation

Outreach Service:

Editor for Aquaculture Research Institute bi-annual newsletter, 2005-present
Article for *Hatchery International Magazine*, 2009
Articles for *Waterlines* (published by the Western Regional Aquaculture Center), 2009
Biosecurity Workshop (instructor), presented to trout industry
Salmon Disease Workshop, Corvalis, OR, July, 2009 (Participating instructor): Intensive 2 wk disease course for fish health professionals
Presented research overview at Idaho Aquaculture Association annual meeting, 2008
Spokesman Review, Article on Coldwater Disease Vaccine development, October, 2006
Idaho Science and Technology newsletter, October, 2006
Columbia Basin Bulletin, October, 2006

Spokesman Review, Article on Burbot Aquaculture, December, 2006
CNR magazine, research highlights, 2006
CNR alumni news, research highlights, 2005, 2006, 2007
UI Research Webpage (Today at UI), Press release describing Burbot aquaculture project, 2004
Twin Falls Times (Ag weekly), Article on research presentation given by Ben LaFrentz at IAA meeting, 2004
Coldwater Disease workshop presented to Aquaculture Industry, CSI Hatchery, Twin Falls, Idaho, 2004
Fish Immunology Workshop, AFS/Fish Health Section, Continuing education, 2000
Twin Falls Times (Ag Weekly), Highlighted Fish Health Class tour of Aquaculture Industry
Trout Disease Workshop, Idaho trout industry, provide shortcourse for industry employees
Totally Wild Television program, Sydney, Australia, segment on Fish Vaccination
Twin Falls Times (Ag Weekly), article highlighting invited seminar for Idaho Aquaculture Association

Community Service:

Annual contribution, Palouse Unit, American Fisheries Society
Taught beginning whitewater kayaking course, University of Idaho Outdoor Program, August 2000

PROFESSIONAL DEVELOPMENT:

Teaching:

Participant in McNair Scholar Program, 2004, 2007-2008
Writing across curriculum (WAC) workshop, January 2000

Scholarship:

Sabbatical application, (accepted 2008) Building international collaborations in aquaculture and fish health through research, teaching, and outreach. (Approved for Spring semester 2011)
Continuing education, AFS/FHS (80+credit hrs – Fish Virology, Histology, Hematology, Immunology, and Neoplasia in Fishes New Molecular Diagnostic Techniques, Early Fish Development, Fish Nutrition, Toxicology, Application of bacterial genomics to fish diagnostics, etc.)
Grant writing workshop, April 2000

Administration/Management:

Associate Director, Aquaculture Research Institute, July 2002-present