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 "naturally occurring" probiotic bacterial strains as feed additives to improve fish health and aid in disease management for aquaculture

SPECIFIC PROJECT FOCUS:

Address critical research questions/objectives important for determining market potential for product. Will work with industry partner toward licensing and patent filing (national and international) for probiotics use in aquaculture.

PROJECT START DATE: 7/1/12	PROJECT END DATE:6/30/13
NAME OF INSTITUTION: University of Idaho	DEPARTMENT: Fish and Wildlife Sciences

ADDRESS: Department of Fish and Wildlife Sciences, PO Box 441136, Moscow, ID 83844-1136

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

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

	NAME:	SIGNATURE:
Authorized Organizational Representative	**Polly J Knutson, Director Office of Sponsored Programs University of Idaho** SM 5-8-12	

Commercializing specific "naturally occurring" probiotic bacterial strains as feed additives to improve fish health and aid in disease management for aquaculture

1. ***Name of Idaho public institution*:** University of Idaho
2. ***Name of faculty member directing project*:** Kenneth Cain
3. ***Has technology been proposed/awarded an Incubation Fund Award*:** Yes

When was original proposal submitted? This project was submitted last year and was awarded funding in March of 2011.

How is this proposal different from the last proposal awarded? The original proposal addressed objectives aimed at key production, storage, and feeding trials for practical application of probiotics to control coldwater disease (CWD) in aquaculture. The work proposed in this proposal will allow completion of any remaining work from year one, but more importantly, address objectives identified by our industry partner as essential for expanding the market potential for this product. Year one experiments are nearly complete, but new findings by our lab suggest additional fish species may benefit from our probiotic bacterial strains. This must be confirmed through feeding trials and disease challenge experiments. We originally anticipated a start-up company being created; however, it became obvious that the capital and required investments to initiate such a venture were not available. This required us to actively seek out an industry partner with experience in the field, knowledge of the regulatory approval process, capabilities to license the technology from UI, and the ability to fully market and commercialize such a product. It turned out that our existing partner "Aquatic Life Sciences" a well know Fish Health Company, was very interested in probiotics and their implication as new tools for fish disease control and management. Since they just licensed patent rights for another product of ours (agreement signed on March 20th, 2012 for CWD vaccine), the addition of probiotics

effective against CWD was logical. They feel that this product may be an effective pre-treatment prior to vaccination and utilizing both for CWD would put them at a distinct advantage over competitors. The combined approach (probiotics feeding of very young fish followed by vaccination) would provide a "complete" disease management package for this disease. In addition, new data from our lab has demonstrated that another fish pathogen (*Flavobacterium columnare*) is inhibited *in vitro* by both probiotics strains. This leaves open the question of possible broad scale application and expansion into the warmwater aquaculture sector since this pathogen causes columnaris disease, a major problem in warmwater fish species (catfish, tilapia, ornamental species, etc.) and coldwater species (trout and salmon). Confirmation of beneficial effects when fed to catfish and tilapia will be confirmed during this proposed award period through collaborations with USDA ARS scientists in Auburn, AL.

4. ***Executive summary:***

Aquaculture accounts for nearly half of seafood consumed worldwide and is the fastest growing sector of agriculture. Idaho leads world production of rainbow trout for foodfish with nearly 80 private facilities in southern Idaho alone and a value of up to $100 million/yr. Disease management in aquaculture often relies on a limited selection of approved antibiotics, which has led to increased antibiotic resistance for many fish pathogens. The most serious disease affecting trout and salmon in the region (and worldwide) is CWD, caused by the bacterium *Flavobacterium psychrophilum*. This is the number one problem for the Idaho trout industry, with losses averaging nearly 30% and costing upwards of $9-10 million annually. 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 consists of "normal"

intestinal bacteria that may inhibit the growth of specific pathogens of interest. Use of these as feed additives could provide an alternative to antibiotic therapy or complement vaccination and/or other disease management strategies. Our lab has identified two probiotic bacterial strains (C6-6 and C6-8) that, when fed to rainbow trout, significantly improve fish health as measured by reduced mortality to CWD (Burbank et al., 2011; Burbank et al., 2012). This has been demonstrated both in the lab and at production hatcheries. In addition, we have recently found that these strains are also capable of inhibiting growth of a closely related fish pathogen *F. columnare* (unpublished data), which is the second leading bacterial disease in the US catfish industry and also affects Idaho's trout industry.

This proposal requests incubation funds to expand prototype testing of probiotics in combination with a CWD vaccine, and determine if this product provides health benefits for other aquaculture species. Our industry partner (Aquatic Life Sciences) is committed to commercializing CWD prevention tools and licensing the rights to the probiotic patent (application filed on April 5th, 2012; PCT/US12/29896), sponsoring regulatory approval processes, and commercializing this product for use in aquaculture. They view the testing proposed here as essential in providing a framework to identify the full market potential of probiotics in salmonids (trout and salmon) and are very excited about the possible benefits for warmwater aquaculture on a national and global scale.

5. ***"Gap" project objectives and total amount requested:***

We are seeking $50,000 of incubation funds to complete prototype testing on C6-6 and C6-8, confirm potential for use of these in warmwater species, and determine effectiveness of early administration of this product followed by vaccination against CWD. The work proposed here will advance the technology readiness level (TRL) of this product from 7 to 8. Our commercialization partner is well positioned to bring this product to market. There are two working hypotheses that form the basis of this proposal. H_1: Early administration of C6-6 and/or

C6-8 to trout in feed followed by vaccination will reduce impact due to CWD. H_2: Feed administration of C6-6 and/or C6-8 to warmwater fish species (catfish and tilapia) will result in reduced impact due to columnaris disease. Specific project objectives of this "Gap" project are to:

1. **Complete any remaining objectives from FY12 funding**
    - **Objectives from year one are nearly complete, but additional trials to fully define optimum administration dose may be required.**
2. **Initiate laboratory and field trials to determine effectiveness of utilizing probiotics in a combined strategy (probiotics followed by vaccination)**
    - **Laboratory and field trials at trout hatcheries in Utah (see letter of support)**
3. **Determine if C6-6 and/or C6-8 are effective at reducing mortality due to columnaris in warmwater aquaculture species.**
    - **Laboratory trials to confirm probiotic inhibition of specific strains of *F. columnare***
    - **Probiotic feeding trials (with our USDA ARS collaborator) using catfish and/or tilapia followed by challenge with *F. columnare***

6. ***Project relationship to home institution priorities:***

This project fits well with UI priorities 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 university strategic plan. 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.

7. ***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 production on average, and if such impacts could be reduced, even by a small margin, it would translate to direct economic benefits 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. Since public and private sector aquaculture in Idaho loses over $10 million annually to CWD, a substantial market for this product exists within the state and beyond. Our lab has a proven track record in licensing and commercializing technology in the field of Fish Health (e.g. diagnostic antibodies, testing protocols, and a fish vaccine). The current product would be the first ever feed delivered probiotic for US aquaculture.

8. ***Partnerships or new company creation:***

As described above, we have an established partnership with the company Aquatic Life Sciences (see letter of support). For product field testing we continue to collaborate with the Utah Division of Wildlife Resources. They have numerous state trout hatcheries that experience CWD on a routine basis. We are also working with the Idaho Department of Fish and Game and they have expressed interest in testing probiotic feeds at their hatcheries in combination with the CWD vaccine. A major collaborator on this proposal will be Dr. Ben LaFrentz, scientist at the USDA ARS laboratory in Auburn, AL, who has access to catfish and tilapia along with appropriate facilities for testing (see letter and appendices).

9. ***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 probiotics, 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: Our probiotics product 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, and possibly warmwater fish producers worldwide. Frost & Sullivan reported that in 2006 the total US animal feed probiotic market was valued at $148.5 million, with aquaculture probiotics use (as water additives) at 5%, an immature but growing market segment. By 2013 they suggest that the animal feed market for probiotics is expected to reach $272.2 million, with aquaculture reaching 30% of the total.

Product description, potential market audience, competition, and market barriers: The product would be a probiotic consisting of one or two live bacterial strains originally isolated as part of the fish's "normal" intestinal flora. The product could be sold in a form that would be mixed directly into fish feed, or possibly added to commercial diets at the feed mill. A market analysis was completed and showed that trout and salmon hatcheries at risk of developing CWD represent a large market of public and private sector operations. If effective for warmwater species experiencing columnaris or similar bacterial diseases, the market would expand dramatically and extend worldwide. Frost & Sullivan suggest that most US competitors would be small companies that are able to create the fermented product and sell directly to the end-user. However, there are no current feed delivered probiotics available for aquaculture in the US. Market barriers may include unforeseen regulatory requirements, producer concerns over application requirements (i.e. mixing into feed), and a general lack of awareness of probiotics in the industry. We feel that regulatory concern can be overcome and our commercialization partner has extensive experience working with US, Canadian, and international regulatory

agencies. A survey of Idaho producers suggested potential barriers, such as feed application, are minimal.

10. ***Technology:***

Current state of technology: Early work showed that after testing 318 bacterial strains isolated from the GI tract of rainbow trout, two candidate probiotics (C6-6 and C6-8) could inhibit *F. psychrophilum in vitro* and reduced mortality from CWD when used as live microbial feed additives. This has been shown repeatedly in the lab, but more importantly field trials have confirmed this under production conditions (Fig 1). Both probiotic strains have been identified as different *Enterobacter spp.* and genetic sequencing shows they are closely related to *E. amnigenus*, a common ubiquitous soil and aquatic bacteria. Following on from early work, incubation funding this past year allowed us to address a number of practical questions. We found that large scale production of our strains is not a limitation, and that it is possible to lyophilize and store the product for extended periods. A current experiment will tell us if our strains (C6-6 and C6-8) are best delivered alone or in combination. Finally, recent work in our lab demonstrated that both strains are capable of inhibiting *F. columnare*, a significant pathogen of both warmwater coldwater fish species. Results are exciting and clearly demonstrate the commercial potential of these probiotics for aquaculture.

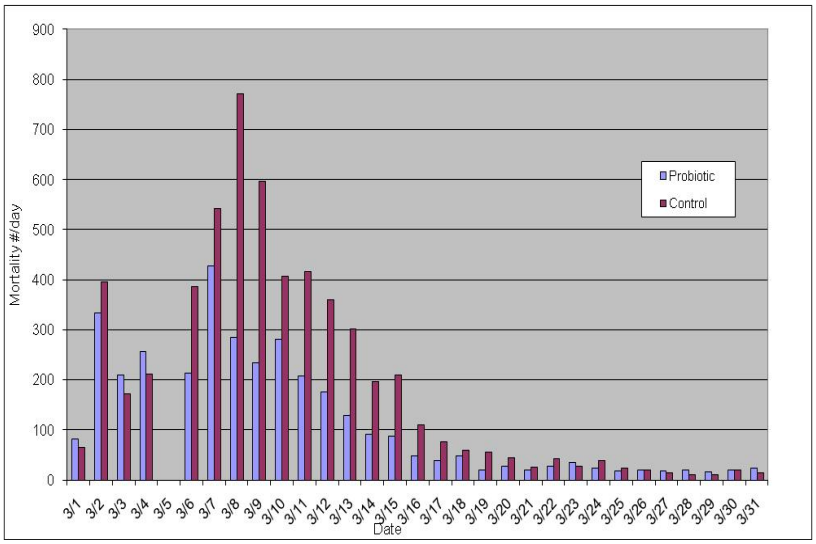

Figure 1. Field testing of C6-6 or a control feed at the Utah Fisheries Experiment station hatchery showing daily mortality of rainbow trout.

Product and market need/intellectual property status: There is a strong need to develop and commercialize probiotics as feed additives for aquaculture. This could provide a replacement for antibiotic use, and be easily administered by mixing into the feed on-site. Alternatively, aquaculture feed companies could be contracted to produce feed pellets that are "top-coated" 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 patent application (PCT/US12/29896) was filed on April 5th, 2012 by the UI.

Potential customers: Since we have demonstrated efficacy of this product for controlling CWD, potential customers include all aquaculture operations rearing 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. If similar results are confirmed for columnaris disease, US customers would include catfish and other warmwater fish producers.

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 was originally provided through USDA WSU/UI Aquaculture Initiative grants and a student scholarship and research award through the UI's McNair Scholar Program. Objectives related to commercialization requirements were addressed this past year through an Idaho Incubation Fund (HERC) award.

11. ***Commercialization partners:***

Aquatic Life Sciences is our industry partner and they are completely committed to solving the problem of CWD for aquaculture producers. They will be selling our recently licensed CWD vaccine and plan to commercialize these probiotics as feed additives, thus providing an additional tool to combat this and possibly other diseases.

12. ***Specific project plan and use of funds:***

To address objectives, we will design a range of experiments that will include both controlled laboratory trials and field trials at hatcheries. We have tested our product at the published dose and slightly lower doses under field conditions; however, we have been unable to fully determine the optimum dose through a titration experiment in the laboratory. This will be conducted early in the project. Following this, we will utilize dose findings to set up a series of treatments that will test the effect of combining probiotics with a vaccine for prevention of CWD in trout. The idea behind this approach is worth noting. Since most trout and salmon are reared on spring water during early life stages, they are not exposed to "natural" bacteria that may be beneficial. By exposing these fish to our probiotics at first feeding, we are able to seed their intestine with our specific strains. This alone would provide benefit if they were exposed to *F. psychrophilum*, but since their immune system is not functional at these early stages they may not develop immunity to CWD if exposed during the fry stage and subsequent outbreaks could occur. If we administer the probiotic in feed for the first 30 days, we would protect fish until their immune system is functional. Then, we can vaccinate them with a CWD vaccine and provide both early protection (offered by feeding probiotics) and long-term protection (conferred by vaccination). Our collaborator at USDA ARS will test probiotics in catfish and/or tilapia. We plan to complete final laboratory and field tests for C6-6 and C6-8 and meet the objectives outlined in the "Gap" project objectives section above.

Proposed budget (see attached): Funds requested will support the project director (approximately one month) to oversee experimental design for laboratory trials and assist with field trials. A graduate student will be supported at the anticipated rate for MS students (approximately 16.67/hr for 20 hrs/wk) for six months to conduct lab experiments, complete his thesis, and defend. Material and supply costs include all consumables, tank rental fees for fish experiments, computer usage fees, etc. Travel support is anticipated to cover one trip to Utah to assist with set up and initiation of field trials. Other travel may include presentations at the annual Idaho Aquaculture Association meeting in Twin Falls and/or regional or national fish health meetings.

Research Timeline 2012-13	J	A	S	O	N	D	J	F	M	A	M	J
Complete remaining dose trials for probiotics against CWD	■	■	■									
Initiate laboratory and field trials using combined probiotics/vaccination		■	■	■	■	■	■	■				
Testing at USDA lab in warmwater aquaculture species					■	■	■	■				
Licensing, regulatory approval, and launching of final product				■	■	■	■	■	■	■	■	■

13. ***Education and outreach:***

A graduate student (Tyson Fehringer) is working on this project and plans to complete his MS in December 2012. Outreach will involve the project director and UI's Aquaculture Extension Specialist (Gary Fornshell). Results will be presented at the annual Idaho Aquaculture Association meeting and various workshops aimed at public and private sector "customers".

14. ***Institutional and other sector support:***

We continue to work closely with the UI Office of Technology Transfer and our industry partner. Strong support from both the public and private sector (see attached letters) is key to successfully licensing, marketing, and commercializing this product. Each partner is providing substantial in-kind support by conducting field trials (Utah), laboratory trials (USDA), or identifying regulatory requirements for product licensing and approval (Aquatic Life Sciences).

APPENDICES:

Facilities and equipment:

UI: 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 College of Natural Resources (CNR), at Aquaculture Research Institute's Wet Lab, and at the U of I Hagerman Fish Culture Experiment Station. The wet lab in the CNR includes a complete disease challenge facility that allows us to conduct the outlined trials for coldwater fish species. All water exiting the U of I campus facility is directly discharged to the Moscow water treatment plant where complete disinfection occurs.

USDA: The Aquatic Animal Health Research Unit operates wet laboratories composed of a hatchery and eleven 900 square feet buildings containing experimental fish tanks. The research is conducted in a modern dry laboratory of 15,000 square feet. The laboratory consists of eleven individual laboratories that are equipped to do immunology, microbiology, pathology, parasitology, nutrition, and molecular biology. Equipment available includes chemical and biological hoods, microscopes, centrifuges, spectrophotometers, incubators, PCR machines, DNA sequencer, electrophoresis units, and equipment for proteomic work.

REFERENCES:

- Burbank, D.R., Shah, D.H., LaPatra, S.E., Fornshell, G. and **Cain, K.D.** 2011. Enhanced resistance to coldwater disease following feeding of probiotic bacterial strains to rainbow trout (*Oncorhynchus mykiss*). *Aquaculture*, 321, 185-190
- Burbank, D.R., LaPatra, S.E., Fornshell, G. and **Cain, K.D.** 2012. Isolation of bacterial probiotic candidates from the gastrointestinal (GI) tract of rainbow trout and screening for *in vitro* inhibitory activity to *Flavobacterium psychrophilum*. *Journal of Fish Diseases* (In press)

BIOGRAPHICAL SKETCHING AND INDIVIDUAL SUPPORT:

University of Idaho
College of Natural Resources

Kenneth Cain

Professor, Department of Fish and Wildlife Sciences
E-mail: kcain@uidaho.edu
Web: http://www.uidaho.edu/cnr/fishwild/kennethcain
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:

- Burbank, D.R., LaPatra, S.E., Fornshell, G. and **Cain, K.D.** 2012. Isolation of bacterial probiotic candidates from the gastrointestinal (GI) tract of rainbow trout and screening for *in vitro* inhibitory activity to *Flavobacterium psychrophilum*. *Journal of Fish Diseases* (In press)
- Burbank, D.R., Shah, D.H., LaPatra, S.E., Fornshell, G. and **Cain, K.D.** 2011. Enhanced resistance to coldwater disease following feeding of probiotic bacterial strains to rainbow trout(*Oncorhynchus mykiss*). *Aquaculture,* 321, 185-190
- **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.
- 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
- **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

NAME (List/PD #1 first)	SUPPORTING AGENCY	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
Cain, Ken	Kootenai Tribe of Idaho (BPA)	$769,935	11/06-1/13	10	Development of Burbot (*Lota lota*) conservation aquaculture and evaluation of disease susceptibility
Cain, Ken; Call, Doug; LaPatra, Scott; Fornshell, Gary; etc.	Western Regional Aquaculture Center	$325,000	10/07-6/12	5	Coldwater disease prevention and control through vaccine development and diagnostic improvements
Cain, Ken	Idaho State Board of Education (Higher Education Research Council – gap funding)	$34,848	4/11-6/12	5	Commercializing autochthonous probiotics to control fish diseases in aquaculture", Idaho State Board of Education, Incubation fund grant
Cain, Ken	Infoscitex corporation (USDA SBIR phase I)	$27,000	8/10-3/12	2	Development of high sensitivity and specificity quantitative aptamer assay for coldwater disease management applications
Hardy, Ron; Cain, Ken; etc.	USDA, ARS	$234,956	9/09-9/12	3	Converting Alaska fish byproducts into value added ingredients and products
	Pending:				
Hardy, Ron; Cain, Ken, Cloud, Joe	IGEM (SBOE)	$927,800	8/12-8/15	4	Enhancing Innovation and Economic Growth of Aquaculture in Idaho
Cain, Ken	Aquatic Life Sciences (private)	$127,764	5/12-9/13	8	Finalizing Critical Needs for Commercialization and Licensing of a Coldwater Disease Vaccine
Cain, Ken	Idaho State Board of Education (Higher Education Research Council – gap funding)	$50,000	7/12-/7/13	8	Commercializing specific “naturally occurring” probiotic bacterial strains as feed additives to improve fish health and aid in disease management for aquaculture

OTHER SECTOR RESOURCE COMMITMENTS:

Aquatic Life Sciences Inc.

May 3, 2012

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,

This correspondence is in support of your Idaho Incubation Fund proposal titled "**Commercializing specific "naturally occurring" probiotic bacterial strains as feed additives to improve fish health and aid in disease management for aquaculture**". We are very familiar with the project, its products and the potential market.

As a University of Idaho alumni and COO of Aquatic Life Sciences, a company located in the Pacific Northwest that is well known for selling, manufacturing and supporting aquatic animal health products worldwide, I am excited about our partnership. Our company feels strongly that these probiotics will be a new potential tool for disease control in aquaculture.

We are especially interested in this project as a means to confirm the potential for your probiotics to be marketed alongside the coldwater disease vaccine that we recently licensed from the University of Idaho. We expect to be selling cold water vaccine in June or July, 2012. The opportunity to also sell probiotics in the future significantly enhances our opportunity for early and ongoing success.

The idea of feeding these probiotics to fish during early life stages when their immune system is not developed followed by vaccination is interesting, and the work you propose here should confirm the effectiveness of this approach to fish health. We have learned from customer experience that there is a significant market for such a product.

We also support the proposed collaboration with the USDA, ARS Auburn lab to further test these probiotics in warm water species such as catfish and tilapia. If proven beneficial for these

species it would open up additional markets in the US, Asia, and elsewhere. We currently enjoy a relationship with several catfish farmers and associations in the United States.

Our company has an internal group that work daily with the various regulatory agencies (i.e. FDA and/or USDA) for approval of such products in the United States, as well as CFIA and the Canadian Food Health agency in Canada. We work with other international regulatory agencies as well.

Based on our experience with you and the University of Idaho, it is our desire to further the relationship by signing a license agreement for the probiotics. Our intent would be to pursue international patent filing to support our worldwide marketing effort.

Your proposal will address critical questions related to the use of probiotics in aquaculture and give us an opportunity to further our support of animal health. We look forward to working with you.

Sincerely,

R. Randal Ownbey/COO
Aquatic Life Sciences
1276 W Freeze Rd
Potlatch, ID 83855

United States Department of Agriculture

Research, Education and Economics
Agricultural Research Service

May 3, 2012

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

Dear Ken:

I would like to confirm my interest in collaborating on the proposed Idaho Incubation Fund Program project entitled, "**Commercializing specific "naturally occurring" probiotic bacterial strains as feed additives to improve fish health and aid in disease management for aquaculture**". The results your laboratory has obtained using the probiotic bacterium as a feed additive to prevent bacterial coldwater disease in salmonids are exciting and provide a strong foundation for the development of this into a commercialized product.

As you know, bacterial diseases are also a limiting factor in the profitability of channel catfish and tilapia aquaculture and account for millions of dollars of losses annually. An effective and commercialized feed additive to prevent or reduce disease impacts would provide warm water aquaculture producers with a valuable tool to integrate into their fish health management programs. I look forward to working with you to determine whether this probiotic bacterium may exhibit beneficial effects in warm water fish species, which would potentially broaden its use. I am willing to carry out *in vitro* assays to confirm the ability of the probiotic bacterial strains to inhibit *Flavobacterium columnare*, and also test these against other bacterial pathogens of channel catfish and tilapia. If these experiments provide encouraging results, we will conduct *in vivo* studies to determine if the probiotic bacterium is effective as a feed additive to prevent bacterial diseases of catfish and tilapia. We are well equipped to complete these studies and look forward to collaborating with the University of Idaho.

Sincerely,

Benjamin R. LaFrentz

Dr. Benjamin R. LaFrentz

Research Molecular Biologist
United States Department of Agriculture
Agricultural Research Service
Aquatic Animal Health Research Unit
Auburn, AL

Aquatic Animal Health Research Unit
990 Wire Road, Auburn, AL 36832-4352
Voice: 334-887-3741 • Fax: 334-887-2983 • E-mail: benjamin.lafrentz@ars.usda.gov

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

May 1, 2012

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 "naturally occurring " probiotic bacterial strains as feed additives to aid in disease management for aquaculture". As you know we are very excited about the results observed in our initial field trials with these probiotics in relation to coldwater disease in our trout hatcheries. We agree to expand this field testing to include early life stage testing followed by application of the UI patented coldwater disease vaccine. The idea that the probiotics could be applied to fish prior to full development of their immune system followed by vaccination would provide a "best management" approach for us and we are excited about such possibilities. We would very much like to see such specific probiotic products commercialized and available for aquaculture.

It is our expectation that we would collaborate directly with you to continue testing strains C6-6 and C6-8 and incorporate vaccination once fish reach 1-2g in size. We will share all data as you work with your industry partner to move forward and 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

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/Professor	$57.44/hr (20 days)			1	$9,190
% OF TOTAL BUDGET: 18.4				SUBTOTAL:	$9,200

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
To be determined/Technician	$15.00/hr	6			$14,440
% OF TOTAL BUDGET: 28.8				SUBTOTAL:	$14,400

D. GRADUATE / UNDERGRADUATE STUDENTS

Name/ Title	Rate of Pay	No. of Months CAL	ACA	SUM	Dollar Amount Requested
Tyson Fehringer	20h/week @ $16.67/hr	6			$8,002
% OF TOTAL BUDGET: 16				SUBTOTAL:	$8,000

E. FRINGE BENEFITS

Rate of Pay (%)	Salary Base	Dollar Amount Requested

23% (Faculty)	$9,650	$2,220
30% (IH with benefits)	$14,440	$4,320
3%	$8,002	$240
	SUBTOTAL:	$6,800

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

Item/Description	Dollar Amount Requested
SUBTOTAL:	

G. TRAVEL:

Dates of Travel (from/to)	No. of Persons	Total Days	Transportation	Lodging	Per Diem	Dollar Amount Requested
August/Sept (Utah)	2	Up to 10	$1000	$1000	$880	$2,880
				SUBTOTAL:		$2,900

H. Participant Support Costs:

	Dollar Amount Requested
1. Stipends	
2. Travel (other than listed in section G)	
3. Subsistence	
4. Other: Tuition (one semester)	$3,060
SUBTOTAL:	$3,100

I. Other Direct Costs:	Dollar Amount Requested
1. Materials and Supplies	$5,588
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:	$5,600
J. Total Costs: (Add subtotals, sections A through I) TOTAL:	$50,000
K. Amount Requested: TOTAL:	$50,000
Project Director's Signature: 	Date: 5/3/12

CURRICULUM VITAE

University of Idaho

NAME: Cain, Kenneth D.

DATE: May 3, 2012

RANK OR TITLE: 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, 2011

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:

2011 - Present, Professor (Aquaculture and Fish Health), University of Idaho
2011 - Present, Honorary Research Associate, Australian Maritime College, University of Tasmania
2002 - Present, Associate Director, Aquaculture Research Institute, University of Idaho
2005 - 2011, Associate Professor (Aquaculture and Fish Health), 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)
Coldwater Fish Culture Workshop, 2011
Fish Immunology Workshop, 2011
Biosecurity workshop, shortcourse/workshop presented to Idaho trout industry, Hagerman, Idaho, Summer 2009
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 2010-2011 academic year: 12 major/program advisees, interacted with 10-25 on-campus students, interacted with 10 or more former students.
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:

Marcy Swain, REU student, 2011
David Burbank, McNair Scholarship, 2008

Graduate Students advised to completion of degree-major professor:

Bikram Ghosh, PhD (University of Tasmania co-advisor), in progress
Neil Ashton, M.S., in progress
Tyson Fehringer, M.S., in progress
Amy Long, Ph.D., in progress
James Barron, M.S., 2011
David Burbank, M.S., 2011
Tarah Johnson, M.S., 2010
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:

Christopher Smith, M.S., (Fish and Wildlife), in progress
Carla Schubiger, Ph.D., (WSU vet med), in progress
Andreas Brezas, (Animal and Vet Sciences), Ph.D., in progress
Karol Gliniewicz, Ph.D., (WSU vet med), in progress
Patricia Dowell, (Animal and Vet Sciences), M.S., in progress
Alejandro Villasante, (Animal and Vet Sciences), Ph.D., in progress
Catherine A. Patricolo (WSU), M.S., in progress
Scott Snyder (Animal and Vet Sciences), Ph.D., 2011
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, 2006-2011
Sudheesh Ponnerassey, 2003-2008
Tanuja Upadhyaya, 2006

Research Technicians:

Neil Ashton, 2011-present
Nate Jensen, 2006-2011
Najeeb Parvez, 2008-2010

Materials Developed:

Coldwater Fish Culture Workshop/shortcourse, 2011
Fish Immunology Workshop/shortcourse, 2011
Biosecurity workshop (notebook/manual and CD), 2009
Current and Emerging Pathogens of Fishes in the Pacific Northwest (notebook/manual and CD), 2007
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:

Hatchery/Wild Fish Interactions, Fish 504, Fall 2010 (Co-taught with Dr. Dennis Scarnecchia)
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.:

Coldwater Fish Culture Workshop (Participating instructor), 2 week shortcourse for aquaculture professionals, attended by fish culturists from IDFG and Nez Perce tribe, Moscow and Hagerman, ID. June/July, 2011
Fish Immunology Workshop (Participating/Invited instructor), 1 week course with laboratory, National Institute of Water and Atmosphere, Wellington, New Zealand, March 2011
JFA304 Aquatic Animal Physiology and Behavior, Guest speaker, University of Tasmania, March 2011
Fish 102, Guest speaker, November 2011
Animal and Veterinary Sciences (AVS 471 – Domestic animal diseases), Guest Lecture, Oct 2010
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, 2008, 2009, 2011

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:

Foltz, J.R., Jensen, N.R., Polinski, M.P., Ireland, S.C. and Cain, K.D. Characterization of egg development by catheterization and consequences for delaying egg fertilization in hatchery reared burbot (*Lota lota*) *North American Journal of Aquaculture* (Accepted)

LaFrentz, B.R., LaPatra, S.E., Call, D.R., and Cain, K.D. Immunization of rainbow trout *Oncorhynchus mykiss* (Walbaum) with a crude lipopolysaccharide extract from *Flavobacterium psychrophilum*. *Journal of Fish Diseases* (Accepted)

Gliniewicz, K, KP Plant, SE LaPatra, BR LaFrentz, K Cain, KR Snekvik and DR Call. 2012. Comparative proteomic analysis of virulent and rifampicin attenuated *Flavobacterium psychrophilum*. *Journal of Fish Diseases* (In Press)

Long, A., Polinski, M.P., Call, D.R., and Cain, K.D. 2012. Validation of Diagnostic Assays to Screen Broodstock for *Flavobacterium psychrophilum* infections. *Journal of Fish Diseases* (In press)

Burbank, D.R., LaPatra, S.E., Fornshell, G. and Cain, K.D. 2012. Isolation of bacterial probiotic candidates from the gastrointestinal (GI) tract of rainbow trout and screening for *in vitro* inhibitory activity to *Flavobacterium psychrophilum*. *Journal of Fish Diseases* (In press)

Snyder, S, Barrows, R., Hill, R., Gaylord, G., Overturf, K. Cain, K.D., and Hardy, R. 2012. Effects of carnosine supplementation to an all-plant protein diet for rainbow trout (*Oncorhynchus mykiss*). *Aquaculture* (In press)

Burbank, D.R., Shah, D.H., LaPatra, S.E., Fornshell, G. and Cain, K.D. 2011. Enhanced resistance to coldwater disease following feeding of probiotic bacterial strains to rainbow trout (*Oncorhynchus mykiss*). *Aquaculture*, 321, 185-190

LaFrentz, B.R., LaPatra, S.E., Call, D.R., Wiens, G.D., and Cain, K.D. 2011. Identification of Immunogenic proteins within distinct molecular mass fractions of *Flavobacterium psychrophilum*. *Journal of Fish Diseases*, 34, 823-830

Lloyd, S.J., LaPatra, S.E., Snekvik, K.R., Cain, K.D., and Call, D.R. 2011. Quantitative PCR demonstrates a positive correlation between a *Rickettsia*-like organism and severity of strawberry disease lesions in rainbow trout (*Oncorhynchus mykiss*). *Journal of Fish Diseases*, 34, 701-709

Jensen, N.R., Anders, P.J., Hoffman, C.A., Porter, L.S., Ireland, S.C., and Cain, K.D. 2011. Performance and macronutrient composition of Age-0 burbot fed four diet treatments. *North American Journal of Aquaculture*, 73:3, 360-368

Neufeld, M.D., Cain, K., Jensen, N., Ireland, S.C., and Paragamian, V.L. 2011. Movement of Lake Origin Burbot Reared in a Hatchery Environment and Released into a Large River. *North American Journal of Fisheries Management* 31, 56-62

Plant, K.P., LaPatra, S.E., Call, D.R., and Cain, K.D. 2011. 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* 34, 247-250

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 transmontan*us 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:

Jensen, N. R., Williams, S. R., Ireland, S. C., Siple, J. T., Neufeld, M. D., Cain, K. D. 2008. Spawning and behavior observations of captive wild burbot *(Lota lota maculosa). Proceedings of the Second International Burbot Symposium* 59, 155-165

LaFrentz, B.R., and Cain, K.D., Coldwater Disease, Extension Bulletin, 2004. Western Regional Aquaculture Consortium (WRAC) 9 pgs.

Simpson, P.R., B.C. Peterson, K.D. Cain, R.W. Hardy, K. Overturf, and T.L. Ott. 2002. Physiological effects of recombinant bovine somatotropin (rbST) in rainbow trout (*Oncorhynchus mykiss*). Growth Hormone and IGF Research. 12(4):234.

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*, using a 2-D electrophoretic approach. BioRadiations 107 19-21.

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*, using a 2-D electrophoretic approach. Bio-Rad Tech Note # 2670.

Cain, K.D., Jones, D.R. and Raison, R.L. 2000. Analysis of antibody-antigen kinetics following immunization of rainbow trout (*Oncorhynchus mykiss*) with a T-cell dependent antigen. Developmental and Comparative Immunology 24 (1) S15.

Cain, K.D., LaPatra, S.E., Shewmaker, B., Jones, J. and Ristow, S.S. 1997. Does chum salmon virus (CSV) conferred resistance to IHNV in rainbow trout occur at mucosal sites? American Fisheries Society/Fish Health Section Newsletter: 25 (2): 2-4.

Ristow, S.S., Cain, K.D. and LaPatra, S.E. 1997. Innate antiviral properties identified in the mucus of rainbow trout (*Onccorhynchus mykiss*) challenged with infectious hematopoietic necrosis virus (IHNV). *9th International Congress of Mucosal Immunology*, Immunology and Cell Biology 75 (1): A59.

Cain, K.D. and Garling, D. 1993. Trout Culture in the North Central Region. Extension Bulletin. North Central Regional Aquaculture Center, U.S.D.A. Fact Sheet Series #108. 8 pages.

Other:

Cain, K.D. 2011. Researchers tackle top trout killer, *Capital Press Article*, August, 2011

Call, D.R., Schubiger, C., Cain, K.D. 2011. What causes Strawberry Disease in rainbow trout? US Trout Farmers, *Trout Talk Newsletter*, Fall 2011

Jensen, N., Ireland, S., Neufeld, M., Anders, P., Jones, R., Paragamian, V., and Cain, K.D. 2010. Hatchery reared burbot released for the first time in British Columbia Canada and Idaho USA. *AFS Fish Culture Section Newsletter*, Winter, Pgs 10-11

Jensen, N., Ireland, S., Neufeld, M., Anders, P., Jones, R., Paragamian, V., and Cain, K.D. 2010. Hatchery reared burbot released for the first time in British Columbia Canada and Idaho USA. *University of Idaho Aquaculture Research Institute Newsletter*, spring, Pgs 1-2

Cain, K.D. and Call, D.R. 2010. Coldwater Disease Research, *Waterlines newsletter*, 16, Pg 10

Call, D.R., Snekvik, K.R., and Cain, K.D. 2010. Strawberry Disease Research. *Waterlines newsletter*, 16, Pg 11

Jensen, N.R. and Cain, K.D. 2009. Burbot: Not just another cod. *Hatchery International Magazine*, 10(3) May/June

Cain, K.D. 2009. Strategies for Control and Prevention of Coldwater Disease, *Waterlines newsletter*, 15(1), Pgs 18-20

Cavender, W.P., Wood, J.S., Powell, M.S., Overturf, K., and Cain, K.D. 2003. A real-time quantitative PCR (QPCR) approach for identifying *Myxobolus cerebralis* and determining infection severity in rainbow trout. Final Technical Report. Montana Water Center (Whirling Disease Foundation), Bozeman, Montana.

Cain, K.D., Grabowski, L., and Reilly, J.J. 2001. Immunomodulatory effects of β-1,3, glucan administered to tilapia (*Oreochromis nilotocus*) in a Spirulina based diet. Internal report. Hartz Mountain Corporation, Bloomfield, New Jersey.

Cavender, W.P., Johnson, K.A., and Cain, K.D. 2001 Distribution of *Myxobolus cerebralis* during the migration period for juvenile anadromous salmonids in the Snake and Salmon Rivers of Idaho. Final Technical Report. Montana Water Center (Whirling Disease Foundation), Bozeman, Montana.

Refereed/Adjudicated (currently scheduled or submitted):

Barren, J.M., Jensen, M.R., Anders, P.J., Egan, J.P., Ireland, S.C. and Cain, K.D. Suppression of cannibalism during larviculture of burbot (*Lota lota maculosa*) through size grading. *North American Journal of Aquaculture* (submitted)

Barren, J.M., Jensen, M.R., Anders, P.J., Egan, J.P., Ireland, S.C. and Cain, K.D. Effects of temperature on the intensive culture performance of larval and juvenile North American burbot (*Lota lota maculosa*). *Aquaculture* (submitted)

Polinski, M., N. Jensen, J. Foltz, S. Ireland and K. Cain. Hydrogen peroxide treatments administered to hatchery reared burbot (Lota lota): assessing treatment regimes from embryonic development through juvenile rearing. *Aquaculture* (submitted)

Barren, J.M., Jensen, M.R., Anders, P.J., Egan, J.P., Ireland, S.C. and Cain, K.D. Effects of stocking density on survival and yield of North American burbot (*Lota lota maculosa*) reared under semi-intensive conditions. *North American Journal of Aquaculture* (submitted)

Neufeld, M.D., Davis, C.A., Cain, K.D., Jensen, N.R., Ireland, S.C. and Lewandowski, C. Evaluation

of Methods for Collection and Fertilization of Burbot Eggs from a Wild Stock for Conservation Aquaculture Operations. *Proceedings of the Third International Burbot Symposium, Journal of Applied Ichthyology* (In Review)

Paragamian, V.L., Laude, C., Cain, K.D. and Jensen, N. A Novel Experiment of Rearing Burbot Larvae in Pens. *Proceedings of the Third International Burbot Symposium, Journal of Applied Ichthyology* (In Review)

Peer Reviewed/Evaluated (currently scheduled or submitted):

Presentations and Other Creative Activities:

Workshop/manual development (since 1999):

Salinas, I., Nowak, B., and Cain, K.D., Fish Immunology Workshop (Notebook/manual), 2011

Hardy, R., Cain, K.D., Powell, M., Fornshell, G., and Patterson, T. Coldwater Fish Culture Workshop (notebook/manual and materials), 2011

Fornshell, G., and Cain, K.D. Biosecurity workshop (notebook/manual and CD), 2009

Cain, K.D., Johnson, K., Heindel, J., Emerging Pathogens of Fishes in the Pacific Northwest, Workshop manual and CD, February 20, 2007

Cain, K.D. and LaFrentz, B.R. Coldwater Disease Workshop and Shortcourse. UI Cooperative Extension System. June 10, 2004.

Cain, K. Overview of the Fish Immune System. Fish Immunology Workshop Manual. AFS/FHS continuing education, June 27, 2000.

Cain, K. Stress and the Immune Response. Fish Immunology Workshop Manual. AFS/FHS continuing education, June 27, 2000.

Cain, K. Bacterial and Viral Diseases in Aquaculture. Trout Disease/Health Management Short Course Manual. UI Cooperative Extension System and Hagerman Fish Culture Experiment Station. September 12-13, 2000, August 2001.

Professional Meeting Papers, Workshops, Showings, Recitals:

Presentations and Posters (since 1999)

Cain et al. 2011. Identification of specific Autochthonous probiotics capable of enhancing resistance to bacterial coldwater disease. (Invited) Northwest Fish Culture Conference, Victoria, BC Canada. December 6-8.

Cain et al. 2011 A potential vaccine for coldwater disease. (Invited) Northwest Fish Culture Conference, Victoria, BC Canada. December 6-8.

Cain et al. 2011 Conservation aquaculture as a critical tool to recover burbot populations in Idaho's Kootenai River. (Invited) Northwest Fish Culture Conference, Victoria, BC Canada, December 6-8

Cain et al. 2011. Identification of specific Autochthonous probiotics capable of enhancing resistance to bacterial coldwater disease. AADAP meeting Bozeman, MT August 1-4.

Cain et al. 2011. Identification of specific Autochthonous probiotics capable of enhancing resistance to bacterial coldwater disease. (Invited) Pacific Northwest Fish Health Protection Committee (PNFHPC) meeting, Portland OR. September 21-22.

Cain et al. 2011 A potential vaccine for coldwater disease. (Invited) Pacific Northwest Fish Health Protection Committee (PNFHPC) meeting, Portland OR. September 21-22.

Cain et al. 2011. Identification of specific Autochthonous probiotics capable of enhancing resistance to bacterial coldwater disease. (Invited) US Trout Farmers and Idaho Aquaculture Association annual conference, Twin Falls, ID September 29-Oct 1.

Cain et al. 2011 A potential vaccine for coldwater disease. (Invited) US Trout Farmers and Idaho Aquaculture Association annual conference, Twin Falls, ID September 29-Oct 1.

Cain, K.D. 2011. Research overview and update. (Invited) University of Tasmania. February 10th, Launceston, Tas, Australia

Cain, K.D. 2011. Fish Health Research and Development. CSIRO laboratories. March, Hobart, Tas, Australia (invited presentation to Salmon industry)

Cain, K.D., 2011. Aquaculture in Idaho and the Pacific Northwest of the US: Research at the University of Idaho. (Invited) Department of Primary Industries, Mount Pleasant Laboratories, May 7th, Launceston, Tas, Australia

Cain et al. 2011 Conservation aquaculture as a critical tool to recover native fish species. May 18th, University of Tasmania, Launceston, Tas, Australia (invited seminar speaker)

Gliniewicz, K, KP Plant, SE LaPatra, KD Cain, KR Snekvik, BR LaFrentz, and DR Call. Comparative proteomic analysis of virulent and rifampicin attenuated strains of *Flavobacterium psychrophilum*. *American Fisheries Society Annual Meeting*, Seattle, WA, 5-7 September 2011.

Swain, MA, A Long, TR Fehringer, BR LaFrentz, DR Call, and KD Cain. Vaccine efficiency in Coho salmon against *Flavobacterium psychrophilum*. Talk presented at the Center for Research on Invasive Species and Small Populations end of summer presentations. Moscow, Idaho, August 4, 2011.

Cain et al., 2011. Assessing probiotic use for the control of *Flavobacterium psychrophilum* in rainbow trout (*Oncorhyncus mykiss*). 1st Australasion Scientific conference on Aquatic Animal Health. (Invited talk), July 5-8

Burbank, D.R., LaPatra, S.E., Fornshell, G. and Cain, K.D., 2011. Assessing probiotic use for the control of *Flavobacterium psychrophilum* in rainbow trout (*Oncorhyncus mykiss*). Eastern Fish Health Workshop. (Invited talk) March.

Long, A, MP Polinski, DR Call, and KD Cain. Validation of Diagnostic Assays to Screen Broodstock for *Flavobacterium psychrophilum* Infection. Talk presented at the *Idaho Chapter of the American Fisheries Society Annual Meeting.* Boise, Idaho, March 2-4, 2011.

Long, A, J Bertolini, C Olson, DR Call, and KD Cain. 2011. Use of Diagnostic Assays to Evaluate Transmission of Bacterial Coldwater Disease. Presented at American Fisheries Society 141st Annual Meeting. Seattle, Washington.

Gliniewicz, K., Plant, K., LaPatra, S.E., Cain, K.D., Snekvik, K.R., LaFrentz, B.R., and Call, D.R. 2011. Comparative Proteomic Analysis of Virulent and Rifampicin Attenuated Strains of *Flavobacterium psychrophilum*. American Fisheries Society Annual meeting, Seattle, WA September.

Johnson, T.J., Parvez, N., Call, D.R., LaFrentz, B.R., Miura, T., and Cain, K.D. (2010)

Confirmation of Safety and Efficacy for a Live Attenuated *Flavobacterium psychrophila* Vaccine. Sixth International Symposium of Aquatic Animal Health, September 5-9th, Tampa, FL

Long, A., Call, D.R., and Cain, K.D. (2010) Use of Diagnostic Assays to Screen Rainbow Trout (*Oncorhynchus mykiss*) Broodstock for *Flavobacterium psychrophilum*. Sixth International Symposium of Aquatic Animal Health, September 5-9th, Tampa, FL

Cain, K.D., Burbank, D.R., Cavender, W.P., Swan, C.M., Wilson, C. and LaPatra, S.E. (2010) Assessing candidate probiotic use for the possible control of *Flavobacterium psychrophilum* in rainbow trout. American Fisheries Society (Fish Health Section) 51st Annual Western Fish Disease Workshop, Corvallis, OR June 22-24

Plant, K.P., LaPatra, S.E., Call, D.R. and Cain, K.D. (2010) Is vaccination with *Flavobacterium psychrophilum* gliding motility protein N (GldN) effective? American Fisheries Society (Fish Health Section) 51st Annual Western Fish Disease Workshop, Corvallis, OR June 22-24

Cain, K.D., Burbank, D.R., Wilson, C. and LaPatra, S.E. (2010) Assessing candidate probiotic use for the possible control of *Flavobacterium psychrophilum* in rainbow trout. Idaho Aquaculture Association annual meeting, Twin Falls, ID June

Johnson, TJ, BR. LaFrentz, DR. Call, and KD Cain (2010). Characterization of an attenuated *Flavobacterium psychrophilum* vaccine. Idaho Chapter of the American Fisheries Society Annual Meeting, Pocatello, ID March 2-5

Gliniewicz, Snekvik, Cain, LaPatra and Call, "Assessing the immune-protective potential of FP1493 against coldwater disease in rainbow trout Washington State University Showcase, March 2010.

Lanier, Shah, Kumar, LaPatra, Gliniewicz, Snekvik, Cain, and Call, "Production of recombinant *in vivo* induced proteins of *Flavobacterium psychrophilum* for development of a coldwater disease vaccine in rainbow trout. Washington State University Showcase, March 2010.

Gliniewicz, Snekvik, Cain, LaPatra, and Call, "Assessing the immune-protective potential of FP1493 against coldwater disease in rainbow trout. American Society for Microbiology, San Diego, CA, 23-27 May 2010.

Gliniewicz, Cain, Snekvik, and Call. "The role of *rpoB* gene in rifampicin attenuation of *Flavobacterium psychrophilum.* 11th Annual College of Veterinary Medicine Research Symposium, October 27, 2010.

Cain, K.D. (2010) Conservation aquaculture as a critical tool to recover burbot populations in Idaho's Kootenai River. Idaho Chapter of the American Fisheries Society Annual Meeting, Pocatello, ID March 2-5

Cain, K.D. (2010) Conservation aquaculture as a critical tool for recovery of burbot populations in the Kootenai River. Kootenai Valley Resource Initiative annual Burbot subcommittee meeting. May 25th, Bonner's Ferry, ID.

Lloyd, S.J., LaPatra, S.E., Snekvik, K.R., Cain, K.D., and Call, D.R. (2010) Quantitative PCR demonstrates a positive correlation between a *Rickettsia*-like organism and severity of strawberry disease lesions in rainbow trout (*Oncorhynchus mykiss*). American Society of Microbiology annual meeting, Mach, San Diego, CA.

LaFrentz BR, Peterson MP, Jensen NR, Cain KD (2010) Conservation aquaculture: a tool for recovering declining fish populations. 2010 USDA-ARS Auburn Location Earth Day

Celebration and Annual Environmental Management System Awareness Training, April 22, Auburn, AL, USA

Gliniewicz, KS, KD Cain, KR Snekvik, and DR Call. The role of *rpoB* in the attenuation of *Flavobacterium psychrophilum* after passage with rifampicin. Poster presented at the *10th Annual College of Veterinary Medicine Research Symposium*, Pullman, WA, October 14, 2009.

Cain, K.D. (2009) Coldwater disease research update. Idaho Aquaculture Association annual meeting, Twin Falls, ID June

Cain, K.D., Jensen, N., Ireland, S., Siple, J. and Neufeld, M. (2009) Development of aquaculture methods for burbot *lota lota* . Idaho Chapter of the American Fisheries Society Annual Meeting, Boise, ID March 4-6

Cain, K.D., LaFrentz, B.R., LaPatra, S.E. and Call, D.R. (2009) Development and characterization of rifampicin resistant *Flavobacterium psychrophilum* strains and their potential as live attenuated vaccine candidates. Aquaculture America, Seattle, WA Feb.15-18

Cain, K.D., Jensen, N., Ireland, S., Siple, J. and Neufeld, M. (2009) Development of intensive culture methods for burbot *lota lota.* Aquaculture America, Seattle, WA Feb.15-18

Barron JM, Jensen NJ, Jones RN, Ireland SC, Siple JT, Neufeld MD, Paragamian VL, Cain KD (2009). Development and Optimization of Culture Techniques for the North American Burbot (*Lota lota maculosa*) US Fish and Wildlife Service Pacific Region Hatchery Management Workshop, November 3-5, Richland, WA

Johnson, TJ., BR. LaFrentz, and KD Cain (2009). Development and optimization of a potential vaccine for *Flavobacterium psychrophilum*, the bacterial agent of cold water disease. Fish Health Section of the American Fisheries Society annual meeting, June 8-10th, Park City, Utah

Johnson, TJ, BR. LaFrentz, DR. Call, and KD Cain (2009). Characterization of an attenuated *Flavobacterium psychrophilum* vaccine. American Fisheries Society annual meeting, Aug 30th-Sept 3rd, Nashville, Tennessee

Burbank DR, LaPatra SE, Fornshell G, Cain KD (2009) Assessing Candidate Probiotic use for the Possible Control of *Flavobacterium psychrophilum* in Rainbow Trout (*Oncorhynchus mykiss*) Joint Meeting of the Fish Health Section and Western Fish Disease Workshop, June 7-10th, Park City, Utah, USA

Long A, Call DR, Cain KD (2009) Comparison of Diagnostic Techniques for Detection of *Flavobacterium psychrophilum* in Ovarian Fluid. Joint Meeting of the Western Fish Disease Workshop and Fish Health Section of the American Fisheries Society Annual Meeting, June 7-10, Park City, Utah.

Plant KP, LaPatra SL, Call D, Cain KD (2009) recombinant protein vaccination with *Flavobacterium psychrophilum* elongation factor Tu and iron-sulphur assembly protein SufB. Western Fish Disease Workshop and AFS Fish Health Section Annual Meeting, June 7-10th, Park City, Utah.

Polinski MP, Johnson KA, Snekvik KR, LaFrentz BR, Cain KD (2009) Investigation into the susceptibility of burbot *Lota lota maculosa* to select aquatic pathogens. Fish Health Section annual meeting and 50th annual Western Fish Disease Workshop of the American Fisheries Society, June 8-11, Park City, UT, USA

Polinski MP, Johnson KA, Snekvik KR, Drennan JD, Batts WN, Cain KD (2009) The

development of a cell line from burbot *Lota lota maculosa* with characterization of susceptibility to IHNV, IPNV, and VHSV. Fish Health Section annual meeting and 50th annual Western Fish Disease Workshop of the American Fisheries Society, June 8-11, Park City, UT, USA

Polinski MP, Johnson KA, Ireland SC, Jensnen NR, Cain KD (2009) Evaluation of formalin and hydrogen peroxide used during egg incubation of burbot *Lota lota maculosa*. Annual Fish Health Section meeting and 50th annual Western Fish Disease Workshop of the American Fisheries Society, June 8-11, Park City, UT, USA

Jensen, N., Ireland, S., Siple, J., Neufeld, M., and Cain, K. (2008) Burbot hatchery design, development and renovations at the University of Idaho. 59th NWFCC, Spokane, WA December 2-4 2008.

Jensen, N., Williams, S., Ireland, S., Siple, J., Neufeld, M., and Cain, K. (2008) Development of intensive culture methods for burbot *Lota lota maculosa*. 59th NWFCC, Spokane, WA December 2-4 2008.

Polinski MP, Johnson KA, Snekvik KR, Ireland SC, Drennan JD, Cain KD (2008) Evaluation of formalin and hydrogen peroxide use during egg incubation. 59th NWFCC, Spokane, WA December 2-4 2008.

Cain, KD, and LaFrentz, BR (2008) Defining acquired immunity to *Flavobacterium psychrophilum*: implications for developing a coldwater disease (CWD) vaccine. 8th International Congress on the Biology of Fish, July 28-August 1, Portland, OR, USA

Cain, KD. (2008) Coldwater Disease Research Update: Vaccine Development. Idaho Aquaculture Association Annual Meeting, June 21, Twin Falls, ID

Polinski MP, Johnson KA, Snekvik KR, Ireland SC, Drennan JD, Cain KD (2008) Investigations into Disease Susceptibility and Diagnostic Tools for Burbot (*Lota lota maculosa*) Fish Health Section of the American Fisheries Society annual meeting, July 15-18th, Prince Edward Island, Canada

Plant, KP, LaPatra, SE, and Cain, KD (2008) Recombinant Protein Vaccination with *Flavobacterium psychrophilum* Heat Shock Proteins 60 and 70 Induces a Strong Antibody Response. 49th Annual Western Fish Disease Workshop of the American Fisheries Society, June 23-25, Seattle, WA, USA

Polinski MP*, Johnson KA, Snekvik KR, Ireland SC, Cain KD (2008) Evaluation of formalin and hydrogen peroxide use during egg incubation and preliminary investigations into diseases susceptibility of burbot (*Lota lota maculosa)* 49th Annual Western Fish Disease Workshop of the American Fisheries Society, June 23-25, Seattle, WA, USA

Polinski MP*, Johnson KA, Snekvik KR, Ireland SC, Drennan JD, Cain KD (2008) Preliminary investigations into disease susceptibility of burbot (*Lota lota maculosa*) Annual Meeting of the Idaho Chapter of the American Fisheries Society, February 6-8, Post Falls, ID, USA

LaFrentz BR, LaPatra SE, Call DR, Cain, KD (2007) Characterization of attenuated strains of *Flavobacterium psychrophilum* generated by selection for rifampicin resistance. 48th Western Fish Disease Workshop and AFS Fish Health Section Annual Meeting, June 4-6, Jackson Lake Lodge, Grand Teton National Park, WY, USA

Plant, K., LaPatra, S., and Cain, K (2007) Heat shock proteins as DNA vaccine candidates against *Flavobacterium psychrophilum*. 48th Western Fish Disease Workshop and AFS Fish Health Section Annual Meeting, June 4-6, Jackson Lake Lodge, Grand Teton

National Park, WY, USA

Lindstrom, N.M., LaFrentz, B.R., Hugunin, H., Call, D.R., and Cain, K.D. (2007) Proteomic analysis of a distinct molecular mass fraction of *Flavobacterium psychrophilum.* 48th Western Fish Disease Workshop and AFS Fish Health Section Annual Meeting, June 4-6, Jackson Lake Lodge, Grand Teton National Park, WY, USA

Cain, K.D., and Call, D.R. (2007) Comparative genomics and proteomics of *Flavobacterium psychrophilum*: Moving toward vaccine development. FY 07 Aquaculture ID and WA Annual Meeting, January 16-17, University Inn, Moscow, ID.

Cain, K.D. (2007) Reproductive aspects associated with the development of a conservation aquaculture program for burbot (*Lota lota maculosa*), 9th Annual Northwest Reproductive Sciences Symposium, March 23, University Inn, Moscow, ID.

Chen, J., LaFrentz, S.A., Davis, M.A., LaPatra, S.E., Cain, K., and Call D.R. (2007) Genetic variation of *Flavobacterium psychrophilum* examined by pulse-field gel electrophoresis. *Flavobacterium* 2007 Workshop, May 2-4, Shepherdstown, WV.

Cain, K., Sudheesh, P.S., LaFrentz, B.R., Call, D.R., Siems, W.F., LaPatra, S.E., and Wiens, G.D. (2007) Identification of potential vaccine target antigens by immunoproteomic analysis of a virulent and non-virulent strain of the fish pathogen *Flavobacterium psychrophilum*. *Flavobacterium* 2007 Workshop, May 2-4, Shepherdstown, WV.

Shah, D.H., Cain, K.D., and Call, D.R. (2007) Effects of codon usage bias on recombinant expression of *Flavobacterium psychrophilum* proteins in *E. coli*. *Flavobacterium* 2007 Workshop, May 2-4, Shepherdstown, WV.

Cain, K.D., LaFrentz, B.R., Lindstrom, N.M., LaPatra, S.E., and Call, D.R. (2007) Electorphoretic and western blot analyses of the lipopolysaccharide and glycocalyx of *Flavobacterium psychrophilum. Flavobacterium* 2007 Workshop, May 2-4, Shepherdstown, WV.

Cain, K.D., Lindstrom, N.M., Hamilton, M.J., House, M.L., and Call, D.R. (2007) A quantitative enzyme-linked immunosorbent assay (ELISA) and filtration-based fluorescent antibody test as potential tools for screening *Flavobacterium psychrophilum* in broodstock. *Flavobacterium* 2007 Workshop, May 2-4, Shepherdstown, WV.

Call, D.R., Soule, M., Shah, D., LaFrentz, S., Cheng, J., Ramsrud, A., Kang, M., LaFrentz, B.R., Cain, K.D., LaPatra, S.E., and Wiens, G.D. (2007) *Flavobacterium psychrophilum* is composed of two distinct gentetic lineages. *Flavobacterium* 2007 Workshop, May 2-4, Shepherdstown, WV.

Lloyd, S., Snekvik, L., St-Hilaire, S., LaPatra, S., Cain, K., and Call, D. (2007) A rickettsia-like organism is associated with strawberry disease lesions in rainbow trout. WSU Research Symposium, Fall 2007.

Cain, K. D. (Presenter & Author), CRB workshop, "Development of Burbot aquaculture techniques", CRB, Pullman, WA. (December 13, 2006).

Cain, K. D. (Presenter & Author), Western Regional Aquaculter Center Meeting, "Coldwater disease prevention and control through vaccine development and diagnostic improvements", Reno, NV. (October 5, 2006).

Cain, K. D. (Author Only), LaFrentz, B. (Presenter & Author), Lindstrom, N. (Author Only), LaPatra, S. (Author Only), Call, D. (Author Only), International Symposium on Aquatic Animal Health, "Analysis of *Flavobacterium psychrophilum* carbohydrate antigens and their potential role in protective immunity", San Francisco, CA. (September 4, 2006).

Cain, K. D. (Author Only), LaFrentz, B. (Presenter & Author), 47th Western Fish Disease Workshop, "An analysis of Flavobacterium psychrophilum carbohydrate antigens and their potential role in protective immunity", Victoria, BC. (June 27, 2006).

Cain, K. D. (Author Only), Maddox, T. (Presenter & Author), 47th Annual Fish Disease Workshop, "Development of autochthonous probiotics to control *Flavobacterium psychrophilum, Aeromonas salmonicida*, and *Yersinia ruckeri* in aquaculture", Victoria, BC. (June 26, 2006).

Cain, K. D. (Presenter & Author), Jensen, N. (Author Only), CRB annual retreat, "Cryopreservation of burbot semen", CRB, Dworshak Dam, Idaho. (June 1, 2006).

Cain, K. D. (Presenter & Author), Call, D. . (Presenter & Author), Aquaculture Initiative annual review, "CWD vaccine development", WSU/UI, Pullman, WA. (March 8, 2006).

Cain, K. D. (Presenter & Author), Aquaculture Initiative annual review, "Development of Probiotics for disease control in aquaculture", WSU/UI, Pullman, WA. (March 8, 2006).

Cain, K. D. (Author Only), LaFrentz, B. (Presenter & Author), Idaho Chapter of the Wildlife Society, Northwest Scection of the Wildlife Society, Northwest Scientific Association, and Northwest Lichenologists Annual Meeting, "An analysis of Flavobacterium psychrophilum carbogydrate antigens and their potential role in protective immunity", Boise, ID. (March 7, 2006).

Cain, K. D. (Author Only), LaFrentz, B. (Presenter & Author), Annual meeting of the Idaho chapter of the American Fisheries Society, "SDS-PAGE and western blot analysis of Flavobacterium psychrophilum carbohydrate antigens and their poteintial role in protective immunity", Idaho Falls, ID. (February 16, 2006).

Cain, K. D. (Presenter & Author), Fish Reproductive Biology monthly meeting, "Understanding transmission factors for WSIV in white stugeon", WSU, Pullman, WA. (January 2006).

Cain, K.D., and Drennan, J.D. 2005. Transmission of White Sturgeon Iridovirus in Kootenai River White Sturgeon (*Acipenser transmontanus*). Center for Reproductive Biology, Fish Reproduction Meeting (*Invited presentation*). December 15.

Jensen, N., Williams, S., Ireland, S., Siple, J., Neufeld, M., and Cain, K.D., 2005. Development of conservation aquaculture strategies for restoration of burbot (*Lota lota maculosa*) in Idaho's Kootenai River. Northwest Fish Culture Conference. Boise, ID. December 2-6.

Cain, K.D., Jensen, N., Williams, S., Anders, P., and Ireland, S. 2005. Conservation aquaculture strategies for restoration of Burbot (*Lota lota*) in Idaho's Kootenai River. American Fisheries Society National Meeting. Anchorage, AK. (*Invited presentation*) September 11-16.

Cain, K.D., Sudheesh, P.S., LaPatra, S.E., Wiens, G.D., LaFrentz, B.R., and Call, D.R. 2005. Identification and expression of an immuno-reactive heat shock protein from *Flavobacterium psychrophilum*. AFS Annual Fish Health Section Meeting,. Minneapolis, MN July 25-28.

Drennan, J.D., LaPatra, S.E., Sampson, C. A., Ireland, S., and Cain, K.D. 2005. Evaluation of Lethal and Non-lethal Sampling for the Detection of WSIV Infection in White Sturgeon (*Acipenser transmontanus*). AFS Annual Fish Health Section Meeting,. Minneapolis, MN July 25-28.

Soule, M., LaFrentz, S., Cain, K.D., LaPatra, S.E., and Call, D.R. 2005. Combining suppression

subtractive hybridization and microarrays to map the intra-specific phylogeny of *Flavobacterium psychrophilum.* AFS 45th Western Fish Disease Workshop, Boise, ID, June 27-29.

Lindstrom, N.M., LaFrentz, S.A., Call, D.R., and. Cain, K.D. 2005. Development of an enzyme-linked immunosorbent assay (elisa) for detection of *Flavobacterium psychrophilum*. AFS 45th Western Fish Disease Workshop, Boise, ID, June 27-29.

Drennan, J.D., LaPatra, S.E., Sampson, C. A., Ireland, S., and Cain, K.D. 2005. Evaluation of lethal and non-lethal sampling for the detection of WSIV infection in Kootenai river white sturgeon (*Acipenser transmontanus*). AFS 45th Western Fish Disease Workshop, Boise, ID, June 27-29.

Cain, K.D., LaPatra, S.E., and Fornshell, G. 2005. Development of autochthonous probiotics to control disease outbreaks in aquaculture. Idaho Aquaculture Association Meeting (*Invited presentation*). June 18.

Cain, K.C., Call, D.R., Sudheesh, P.S., LaFrentz, B.R., LaPatra, S.E., and Soule, M. 2005. Comparative genomics and proteomics of *Flavobacterium psychrophilum*. Annual WSU/UI Aquaculture Review. February 2005.

Cain, K.C., LaPatra, S.E., and Fornshell, G. 2005.Development of autochthonous probiotics to control disease outbreaks in aquaculture. Annual WSU/UI Aquaculture Review. February 2005.

Sudheesh, P.S., LaFrentz, B.R., LaPatra, S.E., Call, D., and Cain, K.D. 2004. Differential proteomic analysis of virulence associated and immunoreactive antigens of the salmonid pathogen, *Flavobacterium psychrophilum*. AFS Annual Fish Health Section Meeting, Kearneysville, West Virginia, July 25-28.

Drennan, J.D., LaPatra, S.E., Siple, J.T., Ireland, S., and Cain, K.D. 2004. Transmission of White Sturgeon Iridovirus in Kootenai River White Sturgeon (*Acipenser transmontanus*). AFS Annual Fish Health Section Meeting, Kearneysville, West Virginia, July 25-28.

Grabowski, L.D., LaPatra, S.E., and Cain, K.D. 2004. Relative Percent Survival and Antibody Response in Tilapia (*Oreochromis niloticus*) Following Immunization and Challenge with *Flavobacterium columnare*. AFS Annual Fish Health Section Meeting, Kearneysville, West Virginia, July 25-28.

LaFrentz, B.R., LaPatra, S.E., Jones, G.R. and Cain, K.D. 2004. An Investigation Into The protective Nature Of *Flavobacterium psychrophilum* Lipopolysaccharide Against Coldwater Disease. AFS Annual Fish Health Section Meeting, Kearneysville, West Virginia, July 25-28.

Cain, K.D., LaFrentz, B.R., Williams, S., Jones, G.R., and LaPatra, S.E. 2004. Transfer of maternally derived antibody to eggs and fry following broodstock immunization with *Flavobacterium psychrophilum* AFS 45th Western Fish Disease Workshop, Juneau, Alaska, June 22-24.

LaFrentz, S.E., Williams, S., Jones, G.R. and Cain, K.D. 2004. Potential for Broodstock Immunization as a Method to Reduce CWD in rainbow trout (*Oncorhynchus mykiss*) Fry. Idaho Aquaculture Association Annual Meeting, June 12-13 (invited presentation)

Cain, K.D., LaFrentz, B.R., and LaPatra, S.E. 2004. Can maternal transfer of immunity enhance disease resistance in rainbow trout fry? World Aquaculture Society Meetings, Honolulu, Hawaii, March 1-5.

Soule, M., LaFrentz, S., Oatley, M., Krug, M., LaFrentz, B., Cain, K., and Call, D. 2004.

Comparative Genetics of Virulent and Avirulent Strains of *Flavobacterium psychrophilum*, Etiological Agent for Coldwater Disease in Salmonids, American Society of Microbiology, annual meeting.

Cain, K.D., LaFrentz, B.R., Jones, G.R., and LaPatra, S.E. 2003. Stimulating protective immunity to *Flavobacterium psychrophilum*. AFS Annual Fish Health Section Meeting and 44th Western Fish Disease Workshop, Seattle, Washington, July 14-17.

Cavender, W.P., Wood, J.S., Powell, M.S., Overturf, K., and Cain K.D. 2003. A quantitative PCR (QPCR) approach to rapidly identify *Myxobolus cerebralis* and determine infection severity in rainbow trout. AFS Annual Fish Health Section Meeting and 44th Western Fish Disease Workshop, Seattle, Washington, July 14-17.

Grabowski, L.D., LaPatra, S.E., and Cain, K.D. 2003. Systemic and mucosal antibody response to *Flavobacterium columnare* vaccine preparations in tilapia (*Oreochromis niloticus*). AFS Annual Fish Health Section Meeting and 44th Western Fish Disease Workshop, Seattle, Washington, July 14-17.

LaFrentz, B.R., LaPatra, S.E., and Cain, K.D. 2003. Characterization of protective antigens of *Flavobacterium psychrophilum.* AFS Annual Fish Health Section Meeting and 44th Western Fish Disease Workshop, Seattle, Washington, July 14-17.

Cain, K.D., Cavender, W.P., and Johnson, K.A. 2003. Understanding *Myxobolus cerebralis* distribution during the migration period for juvenile anadromous salmonids: Implications for the use of propagated fish in positive waters. AFS special symposium: Propagated Fish in Resource Management, Boise, Idaho, June 16-18 (invited presentation)

Cain, K.D., LaFrentz, B.R., Jones, B.R., and LaPatra, S.E. 2003. Identification of vaccine target antigens of *Flavobacterium psychrophilum*, the causative agent of coldwater disease and rainbow trout fry syndrome. World Aquaculture society Annual Meeting, Salvador, Brazil, May 19-23.

LaFrentz, B.R., LaPatra, S.E., Jones, G.R., Congleton, J.L., Sun, B., and Cain, K.D. 2003. Characterizaton of serum and mucosal antibody responses in rainbow trout (*Oncorhynchus mykiss*) following immunization with *Flavobacterium psychrophilum*. 3rd International Symposium on Fish Vaccinology, Bergen, Norway, April 9-11.

Cain, K.D., LaPatra, S.E., and LaFrentz, B.R. 2003. Identification of Immunoprotective Antigens of *Flavobacterium psychrophilum* and the Potential for Broodstock Vaccine Development. WSU/UI Center for Reproductive Biology and National Marine Fisheries Service Mini Symposium, Seattle, Washington, March 20-21 (invited presentation)

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. Whirling Disease Symposium, Seattle, Washington, February 6-7.

Cavender, W.P., Wood, J.S., Powell, M.S., and Cain, K.D. 2003. A quantitative PCR (QPCR) approach to rapidly identify *Myxobolus cerebralis* and determine infection severity in rainbow trout. Whirling Disease Symposium, Seattle, Washington, February 6-7.

Simpson, P.R., Peterson, B.C., Cain, K.D., Hardy, R.W., Overturf, K., and Ott, T.L. 2002. Physiological effects of recombinant bovine somatotropin (rbST) in rainbow trout (*Oncorhynchus mykiss*). First Joint Symposium GH-IGF, Boston, Massachusetts, October 5-9.

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.* 4th International Symposium on Aquatic Animal Health, New Orleans, Louisiana, September 1-5.

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. Enhanced efficacy of an attenuated CWD vaccine following culture in iron limited media. Provisional patent application filed August 25th, 2011, case number 11-019.

Cain, K.D. and Burbank, D.R. Discovery of specific probiotics bacterial strains capable of reducing disease-related mortality in aquaculture. Provisional patent application filed April 7th, 2011.

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), "Development of Burbot (*Lota lota*) conservation aquaculture and evaluation of disease susceptibility", Sponsored by the Kootenai Tribe of Idaho (BPA), Federal, **$167,930** (January 2011 – January 2012)

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)

Cain, Kenneth D (Principal), "Commercializing autochthonous probiotics to control fish diseases in aquaculture", Idaho State Board of Education, Incubation fund grant, **$34,848** (April 2011 – July 2012)

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)

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).

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 2012).

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 2012).

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).

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 2012)

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)

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:

Cain, Kenneth (Principal), Finalizing Critical Needs for Commercialization and Licensing of a Coldwater Disease Vaccine, Research and Development Contract, Aquatic Life Sciences (Private Company), ($127,764)

Cain, Kenneth (Principal), UI ARI Kootenai burbot aquaculture development program. Sponsored by Kootenai Tribe of Idaho (BPA), Federal, ($172,295)

Cain, Kenneth (Principal), Development of Techniques to Culture Pacific Lamprey in the Snake River Basin.

USFWS, ($89,630)

Unfunded:

Cain, Kenneth (Principal), 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)

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 Issued Patent "Vaccines for Diseases of Fish", 2010
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:

2011-present, Co-editor, Special Issue (New and Emerging Diseases in Aquaculture), JARD
2010-present, Executive Editor, *The Journal of Aquaculture Research and Development (JARD)*
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:

Promotion and Tenure committee, Department of Animal and Veterinary Sciences, 2011
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)

Polish Foundation for Sciences
Technology grant program (Greece)
Mississippi State University (Center for Veterinary Medicine)
Minnesota Sea Grant
Maryland Sea Grant
National Research Council (Canada)
Canadian Foundation for Innovation (CFI)
National Science Foundation (SBIR)
USDA (SBIR)
Western Regional Aquaculture Center
Great Lakes Trust Foundation

Outreach Service:

Article for *Capital Press*, 2011
Article for *Trout Talk*, 2011
Coldwater Fish Culture Workshop, 2011
Fish Immunology Workshop, 2011
Invited presentation (5) related to Sabbatical in Australia, 2011
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. (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