FY12 INVITATION
PROPOSAL SUMMARY PAGE

Project Title: Modeling the population dynamics of Prince William Sound herring.

Project Period: October 1, 2011 – September 30, 2016

Primary Investigator(s): Trevor A. Branch

Study Location: School of Aquatic and Fishery Sciences, Box 355020, University of Washington, Seattle WA, 98195, USA.

Abstract:

Estimated Budget:
EVOSTC Funding Requested:
(breakdown by fiscal year and must include 9% GA)

Non-EVOSTC Funds to be used:
(breakdown by fiscal year)

Date: 1 June 2011

(NOT TO EXCEED ONE PAGE)

PROJECT PLAN

I. NEED FOR THE PROJECT

A. Statement of Problem

Robust Pacific herring (*Clupea pallasii*) populations, suitable for exploitation by commercial fisheries, are typically sustained by periodic recruitment of strong year classes into the adult spawning population. However, the Prince William Sound (PWS) herring population has not had a strong recruitment class since 1989, when the Exxon Valdez Oil Spill (EVOS) occurred. In the EVOS settlement herring were identified as an injured resource and they remain listed as an unrecovered species by the EVOS Trustee Council (EVOSTC). Understanding why herring have not recovered in Prince William Sound requires understanding potential bottlenecks in the herring life cycle. The identification of the limiting conditions to herring recovery requires a series of focused process studies combined with monitoring of the natural conditions that affect herring survival.

Described here is a single project that is a part of an integrative program that will enhance the current monitoring efforts of the Alaska Department of Fish and Game (ADF&G), and examine aspects of particular life stages to allow better modeling of herring populations. **The long-term goal of the program is to improve predictive models of herring stocks through observations and research.** While we do not anticipate that there will be a major change in our modeling ability in the next five years, we expect that the combination of monitoring and focused process studies will provide incremental changes over the next twenty years and result in a much better understanding of herring populations by the end of the program.

B. Relevance to 1994 Restoration Plan Goals and Scientific Priorities

The proposed program addresses the goals and priorities outlined in the 1994 Restoration Plan (http://www.evostc.state.ak.us/Universal/Documents/Publications/IHRP%20DRAFT%20-%20July%202010.pdf) and in the FY 2012 invitation for proposals. In particular our program addresses the need to "Conduct research to find out why Pacific herring are not recovering" and "Monitor recovery", listed on page 48 of the 1994 Restoration Plan. It will lead to the development of new tools to improve herring management. The latter will be accomplished by providing the information needed to develop or test biological and physical models of herring growth.

In November 2006, a Herring Steering Committee was formed and tasked with developing a focused Restoration Program that identifies strategies to address recovery and restoration of herring, recognizing that activities in the program must span an ecologically relevant time frame that accounts for herring population dynamics and life history attributes. A draft Integrated Herring Restoration Program (IHRP) was completed in the fall of 2008 and was further refined in July of 2010. The main goal of the program is to determine what, if anything, can be done to successfully recover the Pacific herring in PWS. In order to determine what steps can be taken, the program examines the factors limiting recovery of herring in PWS, identifies and evaluates potential recovery options, and recommends a course of action for achieving restoration.

Based on the recommendations of the IHRP the Trustee Council has stated in the FY12 request for proposals that they have chosen Restoration Option #2, Enhanced Monitoring, as the focus for their research interests. The program aims to meet the goals of this option by utilizing a combination of monitoring efforts to provide more information about the existing stock and process studies to elucidate aspects of the herring life cycle necessary to move us towards an improved modeling approach.

II. PROJECT DESIGN

A. Objectives

This project is designed to complement the "PWS Herring Research and Monitoring" proposal submitted by the Prince William Sound Science Center. The objectives of that program are:

1) *Provide information to improve input to the age-structure-analysis (ASA) model, or test assumptions within the ASA model.* The ASA model is currently used by ADF&G for estimating herring biomass (Hulson et al. 2008). The proposed monitoring efforts are designed to address this objective by either expanding the data available for the existing ASA model or by providing information about factors that determine the size of recruitment events.

2) *Inform the required synthesis effort.* Proper completion of a detailed synthesis means being able to access and manipulate different sources of data and information. We are proposing projects that make data available to all researchers.

3) *Address assumptions in the current measurements.* Many of the existing studies are based on historical or logistical constraints. We are proposing research necessary to put the existing measurements into context spatially and temporally. This effort will allow the design of the most accurate and efficient monitoring program.

4) *Develop new approaches to monitoring.* With technological advances we have the potential to improve our monitoring programs so they require less effort or reduce the need to collect fish.

This modeling program addresses objectives 1, 2 and 3 by examining which data sources provide the most informative inputs to the ASA assessment model, holistically modeling the PWS herring life cycle, identifying possible issues with the assumptions of the measurement program, and examining factors that could determine future herring recruitment.

The specific objectives of this project are to:

a) Determine which datasets provide the most informative information for the ASA model (objective 1).
b) Predict levels of future recruitment, and autocorrelation in recruitment, using information from other herring populations and other species of clupeids (objective 1).
c) Synthesize the data collected from the monitoring program into a holistic model of herring dynamics (objective 2), to determine which life stages the observational program should focus on (objective 3).

B. Procedural and Scientific Methods

Identify the most informative datasets: conduct a management strategy evaluation (e.g. Butterworth & Punt 1999, Sainsbury et al. 2000) to identify which types of data are most informative for the ASA model. This task will comprise developing an operating model (modeling the "truth") to generate data types used by the ASA model (hydroacoustic survey, surveys of milt production, age composition, etc.), particularly the new time series developed as part of this program. For each model run, one type of data will be omitted, a large number of data

sets will be generated (100-1000 depending on the time it takes to run the model), and the ASA model applied to the generated data to produce estimates of abundance. The estimates will then be compared to the underlying "truth" in the operating model to see how well the ASA model performs in the absence of that particular source of data. The end result will be an ordering of input data types from most to least informative, providing critical information to prioritize current and future monitoring efforts.

Predict future levels of recruitment: collate time series of herring abundance and recruitment in Pacific herring stocks, and for stocks of other clupeid species. Conduct a meta-analysis to estimate the average duration that a typical herring stock would be expected to remain at low abundance. Estimate the average level of autocorrelation in herring recruitment from other stocks, to understand how much recruitment covaries from one year to the next. Gather covariates (e.g. length, trophic level, price, latitude, sea surface temperature) to understand which factors influence recruitment in clupeid populations. Much of the data for this task has already been completed in the RAM Legacy stock assessment database (e.g. Branch et al. 2010, 2011, Ricard et al. submitted), but more stocks will be added for the analysis.

Create holistic model of herring dynamics: develop a life stage model to synthesize data from each aspect of the monitoring program, to understand which age groups and sources of mortality are most likely to explain the decline in the abundance of PWS herring. The model will be age-based and include separate terms for each component of mortality. The model will be fitted to time series of abundance at each life history stage and time series of disease prevalence.

These tasks will be conducted on computers by University of Washington students and faculty, who have access to a wide range of in-house fisheries modeling expertise (e.g. faculty members Ray Hilborn, André Punt, Tim Essington). This will allow us to examine statistical modeling, process based modeling, and ecosystem modeling approaches in choosing the best approach for each objective.

C. Data Analysis and Statistical Methods

By working with a well-established measurement program we foresee being able to learn about previous work and have access to historical data more rapidly than if this was a stand-alone project. Thus there will be no need to collect data or analyze data separately from the ongoing efforts of the monitoring program. The only data collection will involve gathering time series of abundance and recruitment for clupeid stocks as described above.

Computer models will be written in a combination of R, a high level language such as C++ or Fortran, and AD Model Builder (ADMB Project 2010) software which can rapidly and efficiently fit models to data.

D. Description of Study Area

The study area includes all of Prince William Sound (N, E, S, and W boundaries of respectively, ~ 61, -145.5. 60, and -149°). However, most of the projects will focus on the four bays (Zaikof, Whale, Eaglek, and Simpson) that were extensively studied during the Sound Ecosystem Assessment study and PWS Herring Survey program (Figure 2). This allows the work to build upon the historical research completed in those bays. These bays also cover four different quadrants of the Sound. We anticipate a potential build out to include other bays or contraction based on the results from the synthesis. As part of the

synthesis effort we will be reviewing the question “What is the appropriate sampling distribution?” as applied to the questions of juvenile herring condition and providing an index of juvenile abundance.

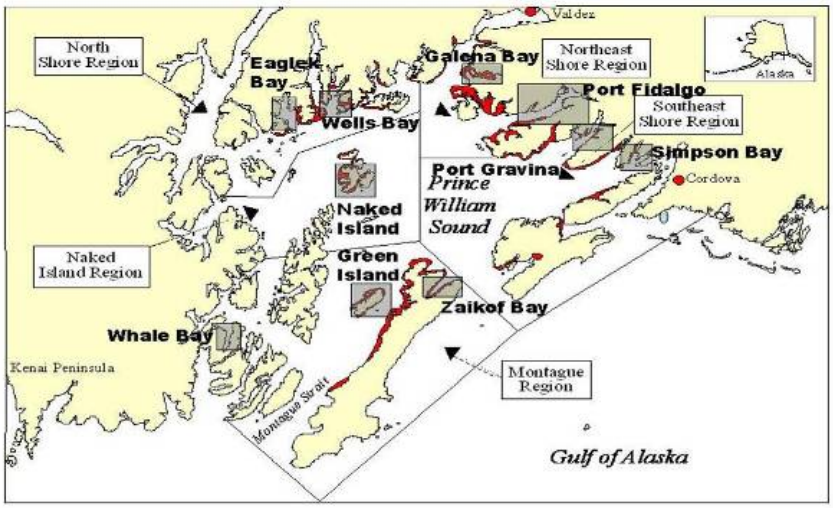

Figure 2. PWS study area, including the four SEA bays (Whale, Zaikof, Eaglek, and Simpson, as well as other bays historically important for juvenile herring.

E. Coordination and Collaboration with Other Efforts

This proposal is structured to be part of a collaborative programmatic effort being led by the Prince William Sound Science Center. Program coordination will primarily be through e-mail and phone communications. Annual meetings are planned in Cordova, tentatively in May, for all investigators to share information between themselves and with the community. These in-person meetings are vital to ensure proper communication among programs.

Dr. Pegau will act as the program team leader and be responsible for ensuring a coordinated and focused research program that leverages other assets whenever possible. He will be responsible for ensuring proper scientific oversight of individual projects and reporting to the EVOSTC. He will lead the development of annual work plans and the synthesis of findings from these programs. He will be responsible for coordinating the efforts of the herring research program with those of the Long-term Monitoring program.

There will be annual Principal Investigator meetings in Cordova each year to provide updates to the oversight panel, improve coordination between projects, and provide outreach and public input opportunities. This meeting will be in the spring so that there is opportunity to provide input on the development of the next year’s work plan. In an effort to be proactive in the scientific oversight we sought input on the development of this proposal from ADF&G, NOAA, Cordova District Fishermens United (CDFU), and others. Team development and input on research direction was also sought at the 2011 Alaska Marine Science Symposium.

The wide array of projects that make up this program required careful integration to ensure the maximum collaboration between projects. Not all observation projects are directly connected to each other, but are connected through the objectives of the program. The full benefits of the linkages will be seen at the points where synthesis efforts occur. As the modeling component to this program the proposed project is one of the main tools for synthesizing the different observation program. It is designed to utilize data from the observation programs and help guide future sampling efforts to maximize the likelihood of achieving the program objectives.

Direct overlap between observation projects occurs in the area of logistics. We intend to have the acoustic surveys, direct capture, and non-lethal collection components sharing a vessel. The direct capture and non-lethal collection are intended to provide validation to the acoustics. The direct capture component will be responsible for providing fish to the RNA condition, energetic condition, disease research, fatty acid indicators, and genetic stock indicator projects. Another direct project overlap occurs between the herring scale analysis and primiparous herring projects, which will share growth information as determined from the scales. The combined efforts will lead to a greater number of scales becoming digitized and improving the statistics for both projects. All projects will also interact with the data management efforts to ensure the data is properly archived and maintained.

Indirect project overlap occurs between projects through the scheduling. Projects like the genetic stock indicators are pushed back in the cycle to ensure that the methodologies used by the direct capture program are mature enough to ensure collection of the required samples. Non-lethal collection is also later in the program to ensure new direct capture techniques are fully tested. Fish collected from the RNA and energetics intensive studies will also be used by the fatty acid indicator project. The acoustic tagging project is early in the program to take advantage of the acoustic receiver array that is in place and has a limited life span. Some projects like the disease research component also start later in the program because of coordination with the existing herring monitoring program. We worked hard to ensure that there isn't duplication between the proposed program and the existing program. One apparent exception is the RNA and energetic condition intensives. By moving these projects early in the program we intend to fill what is seen as a major gap in the existing program and hopefully more quickly resolve the information value that each project provides.

Coordination with the EVOSTC Long-term Monitoring program is critical to the success of the herring program. The ability to develop a predictive tool using the juvenile condition component requires an understanding of when feeding may occur and hence the need to coordinate with the oceanographic monitoring component. Predation by whales, fish, and birds are also considered potential factors inhibiting the recovery of herring. In that regard we will be looking to the monitoring program for information on the changes in the predator population base. That information will be critical if the herring program chooses to focus on predation during future efforts. The forage fish component and our efforts to develop an index of juvenile herring populations must inform each other. We expect that our hydroacoustic surveys and direct capture efforts will help provide measures of total fish biomass as well as forage fish populations. We will also work together to identify historical data that both programs would benefit from as part of the data management efforts. Throughout the proposal writing effort, the herring and long-term monitoring efforts led by Kris Holderied have been working together to identify how the two programs can inform and complement each other.

Other important programs for coordinating with are the existing PWS herring survey program and existing ADF&G herring research. This program has been developed with input from both of these programs and the focus of this proposal is extending the interpretation of the data from those two programs. The Herring Survey program will still be operating in FY12 and FY13. There are field observations scheduled in FY12 and in FY13 funds are strictly for analysis and report writing. Included in the report writing is a synthesis of previous and current research. This report will be finished in FY13 and be the basis for the synthesis required under this request for proposals.

III. SCHEDULE

A. Project Milestones

All projects will be conducted simultaneously and are interlinked. The dates given are the expected dates of submission of scientific papers, but preliminary results will be used to improve the monitoring efforts as they are generated.

Objective 1. Create life history model of herring dynamics.
To be met by September 2014

Objective 2. Identify the most informative datasets using management strategy evaluation.
To be met by September 2015

Objective 3. Predict future levels of recruitment from other herring and clupeid stocks.
To be met by September 2016

B. Measurable Project Tasks

Specify, by each quarter of each fiscal year, when critical project tasks (for example, sample collection, data analysis, manuscript submittal, etc.) will be completed. This information will be the basis for the quarterly project progress reports that are submitted to the Trustee Council Office. Please format your schedule like the following example.

FY12, 1st quarter (October 1, 2013-December 31, 2013)

December 31:	Advertise position to potential graduate students
FY12, 2nd quarter	
March 31:	Offer graduate student place in SAFS program
FY12, 3rd quarter	
May:	Annual Cordova meeting with broader project PIs
FY12, 4th quarter	
August	Annual report: summary of data available for modeling, preliminary model development
FY13, 1st quarter	
October	Student registers, begins quantitative training and coursework
FY13, 2nd quarter	
January	Annual Marine Science Symposium, Anchorage
FY13, 3rd quarter	
May	Annual Cordova meeting with broader project PIs
FY13, 4th quarter	
August	Annual report: preliminary life-history model
December	Student completes required modeling and quantitative courses

FY14, 1st quarter (October 1, 2013-December 31, 2013)

September	Preliminary examination of most informative datasets
FY14, 2nd quarter	
January	Annual Marine Science Symposium, Anchorage
March	Draft manuscript: life history model of herring dynamics
FY14, 3rd quarter	
May	Annual Cordova meeting with broader project PIs
June	Student completes all required coursework and milestones
FY14, 4th quarter	
August	Annual report
September	Manuscript submission: life history model of herring dynamics
FY15, 1st quarter (October 1, 2014-December 31, 2014)	
December	Finalize gathering of time series of abundance and recruitment for herring stocks and other clupeids
FY15, 2nd quarter	
January	Annual Marine Science Symposium, Anchorage
March	Draft manuscript: identification of most informative datasets using management strategy evaluation
FY15, 3rd quarter	
May	Annual Cordova meeting with broader project PIs
FY15, 4th quarter	
September	Manuscript submission: identification of most informative datasets using management strategy evaluation
FY16, 1st quarter (October 1, 2015-December 31, 2015)	
FY16, 2nd quarter	
January	Annual Marine Science Symposium, Anchorage
March	Draft manuscript: predictions of herring recruitment and autocorrelation in herring recruitment
FY16, 3rd quarter	
May	Annual Cordova meeting with broader project PIs
FY16, 4th quarter	
August	Final project report
September	Manuscript submission: predictions of herring recruitment and autocorrelation in herring recruitment

References

Branch, T. A., R. Watson, E. A. Fulton, S. Jennings, C. R. McGilliard, G. T. Pablico, D. Ricard, and S. R. Tracey. 2010. The trophic fingerprint of marine fisheries. Nature 468:431-435.

Branch, T. A., O. P. Jensen, D. Ricard, Y. Ye, and R. Hilborn. 2011. Contrasting global trends in marine fishery status obtained from catches and from stock assessments. Conservation Biology doi: 10.1111/j.1523-1739.2011.01687.x.

Butterworth, D. S. and A. E. Punt. 1999. Experiences in the evaluation and implementation of management procedures. ICES Journal of Marine Science 56:985-998.

Ricard, D., C. Minto, J. K. Baum, and O. P. Jensen. Submitted. RAM Legacy: a new global stock assessment database for exploited marine species. Fish and Fisheries.

Sainsbury, K. J., A. E. Punt, and A. D. M. Smith. 2000. Design of operational management strategies for achieving fishery ecosystem objectives. ICES Journal of Marine Science 57:731-741.

III. BUDGET NARRATIVE

Funds are requested for FY12-FY16, but most of the costs are in FY13-FY16 when the graduate student is hired. Indirect costs are 54.5%.

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED
Personnel	$20,734.0	$34,445.7	$35,823.5	$37,256.4	$38,746.7	$167,006.3
Travel	$982.0	$3,636.0	$8,194.0	$7,812.0	$8,508.0	$29,132.0
Contractual	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Commodities	$200.0	$16,884.0	$20,552.4	$21,286.5	$22,050.0	$80,972.9
Equipment	$0.0	$4,000.0	$0.0	$0.0	$0.0	$4,000.0
Indirect Costs (*will vary by proposer*)	$11,944.2	$20,863.5	$25,188.5	$25,761.3	$26,952.8	$110,710.4
SUBTOTAL	$33,860.2	$79,829.2	$89,758.4	$92,116.2	$96,257.5	$391,821.6
General Administration (9% of subtotal)	$3,047.4	$7,184.6	$8,078.3	$8,290.5	$8,663.2	$35,263.9
PROJECT TOTAL	$36,907.6	$87,013.8	$97,836.7	$100,406.7	$104,920.6	$427,085.5
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

FY12 Justification:

Personnel ($20,734):

Two months for Branch to review literature, compile data, conduct preliminary data analysis, and develop preliminary models of Prince William Sound herring. Since it is too late to identify and admit a graduate student in September 2011, Branch will conduct analyses in FY12 and then train the graduate student to complete and extend the analyses in subsequent years. Tow months at monthly salary of $8150 per month, plus 27.2% benefits, assuming no cost-of-living increase from FY11 salary ($20,734).

Travel ($982):

Travel funds for Branch to attend annual PI meeting in Cordova in May 2012.

Commodities ($200):
Long distance phone calls, photocopying, printer cartridges etc. ($200).

FY13 Justification:
Personnel ($34,446):
One month for Branch to supervise graduate student and for modeling (monthly salary $8,476, plus 27.2% benefits, includes 4% cost-of-living increase from FY12).
Twelve months of PhD student research assistant support to conduct research (monthly salary $1972, plus 16.2% benefits, includes 4% cost-of-living increase from FY12).

Travel ($3636):
Travel funds for Branch and graduate student to attend annual PI meeting in Cordova in May 2012 ($1964).
Travel funds for graduate student to attend Annual Marine Science Symposium in Anchorage ($1672).

Commodities ($16,884):
Long distance phone calls, photocopying, printer cartridges etc. ($200).
Tuition for graduate student, assuming 16% increase in tuition over FY12 ($16,684). Increase assumed to be the same as increase from FY11 to FY12 (due to budget cuts in Washington State).

New Equipment ($4000):
Laptop computer, monitor, associated software for graduate student ($2000).
High speed desktop computer for running lengthy simulations, monitor, to be shared between student and Branch ($2000).
Equipment costing more than $2000 is not subject to University of Washington indirect costs of 54.5%.

FY14 Justification:
Personnel ($35,824):
One month for Branch, 12 months of PhD student, justification as in FY13 except including 4% cost-of-living increase.

Travel ($8194):
Travel funds for Branch and graduate student to attend annual PI meeting in Cordova in May 2012 ($1964).
Travel funds for Branch and graduate student to attend Annual Marine Science Symposium in Anchorage ($3344).
Travel funds for Branch and graduate student to attend American Fisheries Society conference in Little Rock Arkansas ($2886).

Commodities ($20,552):
Publication charges for papers (page charges, color page charges, open access charges). ($2000).
Long distance phone calls, photocopying, printer cartridges etc. ($200).
Tuition for graduate student, assuming 10% increase in tuition over FY13 ($18,352).

FY15 Justification:
Personnel ($37,256):
One month for Branch, 12 months of PhD student, justification as in FY14 except including 4% cost-of-living increase.

Travel ($7812):
Travel funds for Branch and graduate student to attend annual PI meeting in Cordova in May 2012 ($1964).
Travel funds for Branch and graduate student to attend Annual Marine Science Symposium in Anchorage ($3344).
Travel funds for Branch and graduate student to attend Mote Marine Symposium in Sarasota Florida to present results ($2504).

Commodities ($21,287):
Publication charges for papers (page charges, color page charges, open access charges). ($2000).
Long distance phone calls, photocopying, printer cartridges etc. ($200).
Tuition for graduate student, assuming 5% increase in tuition over FY14 ($19,086).

FY16 Justification:
Personnel ($38,747):
One month for Branch, 12 months of PhD student, justification as in FY15 except including 4% cost-of-living increase.

Travel ($8508):
Travel funds for Branch and graduate student to attend annual PI meeting in Cordova in May 2012 ($1964).
Travel funds for Branch and graduate student to attend Annual Marine Science Symposium in Anchorage ($3344).
Travel funds for Branch and graduate student to attend American Fisheries Society annual meeting, venue to be arranged ($3200).

Commodities ($22,050):
Publication charges for papers (page charges, color page charges, open access charges). ($2000).
Long distance phone calls, photocopying, printer cartridges etc. ($200).
Tuition for graduate student, assuming 5% increase in tuition over FY15 ($19,850).

Indirect costs (54.5%)
Federal cost recovery at the University of Washington has been set at 54.5%, and is assumed to remain at this level throughout the grant. Indirect is not applied to tuition or to capital equipment expenses.

Trevor A. Branch

(Principal Investigator)

Address: School of Aquatic and Fishery Sciences, Box 355020, University of Washington, Seattle, WA, 98195
Telephone: 206-221-0776, Fax: 206-685-7471
Email address: tbranch@uw.edu

Education

University of Cape Town	Zoology and Computer Science	B.Sc.	1994
University of Cape Town	Zoology	B.Sc.(Hons)	1995
University of Cape Town	Conservation Biology	M.Sc.	1998
University of Washington	Aquatic and Fishery Sciences	Ph.D.	2004

Employment (Position, institution, start and end year):

2010–present	Assistant Professor, School of Aquatic and Fishery Sciences, Univ. of Washington
2006–2010	Research Scientist, School of Aquatic and Fishery Sciences, Univ. of Washington
2005–2006	Research Officer, Marine Resource Assessment and Management Group, Department of Mathematics and Applied Mathematics, University of Cape Town

Professional Recognition (Societies, honors and awards):

Associate Editor for Animal Conservation, 2011-present.

Invited participant to Scientific Committee meetings of the International Whaling Commission, 2000–2008, advising on abundance, current status, and trends of Antarctic minke whales, Antarctic blue whales and other large cetaceans.

Consultant to Independent Scientific Advisory Panel for Commission for Conservation of Southern Bluefin Tuna, 2004–present.

Young Investigator award for best oral presentation at the Mote Symposium, November 2004.

Faculty merit award for best PhD student, School of Aquatic and Fishery Sciences, University of Washington, 2004.

Reviewer for 22 journals including Science, Canadian Journal of Fisheries and Aquatic Sciences, Proceedings of the Royal Society B, Fisheries Research, ICES Journal of Marine Science, Fish and Fisheries, Ecology, and Marine Ecology Progress Series.

Graduate students and post-doctorates supervised:

M.S. Advisor, Cole Monnahan (2011-present), Quantitative Ecology and Resource Management (QERM) interdisciplinary program.

Ph.D. committee member: Kotaro Ono (2011-present), School of Aquatic and Fishery Sciences, University of Washington.

M.S. Committee member: Curry Cunningham (2011-present), School of Aquatic and Fishery Sciences, University of Washington.

Selected publications since 2009 (total = 34):

Branch, T.A., Watson, R., Fulton, E.A., Jennings, S., McGilliard, C.R., Pablico, G.T., Ricard, D., & Tracey, S.R. 2010. The trophic fingerprint of marine fisheries. Nature. 468:431-435.

Worm, B., Hilborn R., Baum, J.K., **Branch, T.A.**, Collie, J.S., Costello, C., Fogarty, M.J., Fulton, E.A., Hutchings, J.A., Jennings, S., Jensen, O.P., Lotze, H.K., Mace, P.M., McClanahan, T.R., Minto, C., Palumbi, S.R., Parma, A.M., Ricard, D., Rosenberg, A.A., Watson, R. & Zeller, D. 2009. Rebuilding global fisheries. Science. 325:578-585.

Sethi, S. A., **Branch, T.A.** & Watson, R. 2010. Fishery development patterns are driven by profit but not trophic level. Proceedings of the National Academy of Sciences U.S.A. 107:12163-12167.

Branch, T.A., Jensen, O.P., Ricard, D., Ye, Y. & Hilborn, R. 2011 Contrasting global trends in marine fishery status obtained from catches and from stock assessments. Conservation Biology. doi: 10.1111/j.1523-1739.2011.01687.x

Froese, R., **Branch, T.A.**, Proelβ, A., Quaas, M., Sainsbury, K. & Zimmermann, C. 2011. Generic harvest control rules for European fisheries. Fish and Fisheries. doi: 10.1111/j.1467-2979.2010.00387.x

Branch, T.A. & Hilborn, R. 2010. A general model for reconstructing salmon runs. Canadian Journal of Fisheries and Aquatic Sciences. 67:886-904. doi: 10.1139/F10-032

Branch, T.A. 2009a. How do individual transferable quotas affect marine ecosystems? Fish and Fisheries. 10:39-57.

Branch, T.A. 2009b. Differences in predicted catch composition between two widely used catch equation formulations. Canadian Journal of Fisheries and Aquatic Sciences. 66: 126-132. doi:10.1139/F08-196

Collaborators and co-editors in the last 48 months

Abbott, J. (Arizona State University), Abubaker, E.M.N. (Sudan), Allison, C. (IWC, U.K.), A'Mar, Z.T. (UW), Anderson, R.C. (Maldives), Ashe, E., (U.K.), Baker, A.N. (New Zealand), Baker, M.R. (UW), Bannister, J.L. (W. Australian Museum) , Baum, J.K. (Scripps Inst. Oceanography), Best, P.B. (South African Museum), Borsa, P. (New Caledonia), Bravington, M. (CSIRO, Australia), Brownell Jr, R.L. (NOAA), Burton, C.L.K. (private, Australia), Butterworth, D.S. (Univ. Cape Town, South Africa), Cabrera, E. (Centro de Conservacion Cetacea, Chile), Carlson, C.A. (College of the Atlantic), Childerhouse, S. (Department of Conservation, New Zealand), Clarke, E. (NOAA), Clark, S. (Sea World), Collie, J.S. (Univ. Rhode Island), Costello, C. (UC Santa Barbara), Essington, T.E. (UW), Findlay, K.P. (Univ. Cape Town, South Africa), Fogarty, M.J. (NOAA), Froese, R. (Leibniz Inst. Mar. Sci., Germany), Fulton, E.A. (CSIRO, Australia), Galletti Vernazzani, B. (Centro de Conservacion Cetacea, Chile), Gerrodette, T. (NOAA), Gill, P.C. (Blue Whale Study, Australia), Haynie, A.C. (NOAA), Hammond, P. (U.K.), Hedley, S. (U.K.), Hilborn R. (UW), Hollowed, A. (NOAA), Holland, D.S. (NOAA), Holtgrieve, G.W. (UW) , Hucke-Gaete, R. (Universidad Austral de Chile), Hoyt, E. (Whale & Dolphin Cons. Soc.), Hutchings, J.A. (Dalhousie Univ., Canada), Ianelli, J. (NOAA), Ilangakoon, A.D. (Sri Lanka), Jannot, J. (NOAA), Jenner, K.C.S. (Centre for Whale Research, Australia), Jenner, M.-N.M. (Ctr. Whale Res, Australia), Jennings, S. (Ctr. Env. Fish. Aqu. Res., U.K.), Jensen, O.P. (Univ. Rutgers), Joergensen, M. (Denmark), Kahn, B. (Indonesia), Kato, H. (Tokyo Univ. Mar. Sci. Tech., Japan), Kendall, N.W. (UW), Krkošek, M. (New Zealand), Ljungblad, D.K. (private), Lotze, H.K. (Dalhousie Univ., Canada), Mace, P.M. (Min. Fisheries, New Zealand), Matsuoka, K. (Inst. Cet. Res., Japan), Maughan, B. (U.K.), McCauley, R.D. (Curtin Univ., Australia), McClanahan, T.R. (Wildlife Cons. Soc., Kenya), McGilliard, C.R. (UW), McKay, S. (Deakin Univ., Australia), Melvin, E. (UW), Mikhalev, Y.A. (South-Ukrainian Pedagogical Univ.), Minto, C. (Dalhousie Univ., Canada), Miyashita, T. (Natl Res. Inst. Far Seas Fish., Japan), Mkango, S. (Univ. Cape Town, South Africa), Morrice, M.G. (Deakin Univ., Australia), Nishiwaki, S. (Inst. Cet. Res., Japan), Noren, D. (NOAA), Norris, T.F. (private), Pablico, G. (WorldFish Cntr., Philippines), Palacios, D.M. (NOAA), Palumbi, S.R. (Stanford Univ.), Parma, A.M. (Centro Nacional Patagónico, Argentina), Proelβ, A. (Germany), Quaas, M. (Germany), Quinn, T.P. (UW), Ranjan, R. (UW), Rankin, S. (NOAA), Ricard, D. (Dalhousie Univ., Canada), Rosen, D. (UBC, Canada), Rosenberg, A.A. (Univ. New Hampshire), Sainsbury, K. (Australia), Samaran, F. (Cntr. d'Etudes Biol. Chize, France), Schindler, D.E. (UW), Sethi, S.A. (UW), Stafford, K.M. (UW), Sturrock, V.J. (Australia), Thiele, D. (Deakin Univ. Australia), Tormosov, D. (Russia), Tracey, S.R. (Univ. Tasmania), Van Waerebeek, K. (Peruvian Cntr. Cet. Res.), Warneke, R.M. (Australia), Watson, R. (Univ. British Columbia), Williams, R. (Canada), Worm, B. (Dalhousie Univ., Canada), Ye, Y. (FAO, Italy), Zeller, D. (Univ. British Columbia), Zerbini, A.N. (NOAA), Zimmermann, C. (Germany).

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED
Personnel	$20,734.0	$34,445.7	$35,824	$37,256.4	$38,746.7	$167,006.3
Travel	$982.0	$3,636.0	$8,194.0	$7,812.0	$8,508.0	$29,132.0
Contractual	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Commodities	$200.0	$16,884.0	$20,552.4	$21,286.5	$22,050.0	$80,972.9
Equipment	$0.0	$4,000.0	$0.0	$0.0	$0.0	$4,000.0
Indirect Costs (*will vary by proposer*)	$11,944.2	$20,863.5	$25,188.5	$25,761.3	$26,952.8	$110,710.4
SUBTOTAL	$33,860.2	$79,829.2	$89,758.4	$92,116.2	$96,257.5	$391,821.6
General Administration (9% of subtotal)	$3,047.4	$7,184.6	$8,078.3	$8,290.5	$8,663.2	$35,263.9
PROJECT TOTAL	$36,907.6	$87,013.8	$97,836.7	$100,406.7	$104,920.6	$427,085.5
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

COMMENTS: In this box, identify non-EVOSTC funds or in-kind contributions used as cost-share for the work in this proposal. List the amount of funds, the

FY12-16

Program Title: Modeling the population dynamics of Prince William Sound herring
Team Leader: Trevor A. Branch

FORM 3A
NON-TRUSTEE AGENCY SUMMARY

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Trevor A. Branch	Assistant Professor	2.0	10367.0		20,734.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	10367.0	0.0	
				Personnel Total	$20,734.0

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Travel Seattle to Cordova, annual PI meeting	307.0	1	3	225.0	982.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$982.0

FY12

Program Title:
Team Leader:

FORM 3B
PERSONNEL & TRAVEL DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Long distance telephone, photocopying, printer cartridges etc.	200.0
Commodities Total	$200.0

FY12

Program Title:
Team Leader:

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY13

Program Title:
Team Leader:

FORM 3B
EQUIPMENT DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Trevor A. Branch	Assistant Professor	1.0	10781.7		10,781.7
To be arranged	Research Assistant	12.0	1972.0		23,664.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	12753.7	0.0	
				Personnel Total	$34,445.7

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Travel Seattle to Cordova, annual PI meeting	307.0	2	6	225.0	1,964.0
Marine Science Symposium	307.0	1	7	195.0	1,672.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$3,636.0

FY13

Program Title:
Team Leader:

FORM 3B
PERSONNEL & TRAVEL DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

Contractual Costs: Description		Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required.	**Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Tuition for graduate student	16,684.0
Long distance telephone, photocopying, printer cartridges etc.	200.0
Commodities Total	$16,884.0

FY13

Program Title:
Team Leader:

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
Laptop computer, monitor, associated software	1.0	2,000.0	2,000.0
High speed desktop computer, monitor, for simulations	1.0	2,000.0	2,000.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$4,000.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY14

Program Title:
Team Leader:

FORM 3B
EQUIPMENT DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 12-FY16

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Trevor A. Branch	Assistant Professor	1.0	11212.9		11,212.9
To be arranged	Research Assistant	12.0	2050.9		24,610.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	13263.8	0.0	
				Personnel Total	$35,823.5

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Travel Seattle to Cordova, annual PI meeting	307.0	2	6	225.0	1,964.0
Marine Science Symposium	307.0	2	14	195.0	3,344.0
AFS symposium, Little Rock Arkansas	400.0	2	14	149.0	2,886.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$8,194.0

FY14

Program Title:
Team Leader:

FORM 3B
PERSONNEL & TRAVEL DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Publication charges for scientific papers, page charges and color page charges	2,000.0
Tuition for graduate student	18,352.4
Long distance telephone, photocopying, printer cartridges etc.	200.0
Commodities Total	$20,552.4

FY14

Program Title:
Team Leader:

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY15

Program Title:
Team Leader:

FORM 3B
EQUIPMENT DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Trevor A. Branch	Assistant Professor	1.0	11661.5		11,661.5
To be arranged	Research Assistant	12.0	2132.9		25,595.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	13794.4	0.0	
				Personnel Total	$37,256.4

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Travel Seattle to Cordova, annual PI meeting	307.0	2	6	225.0	1,964.0
Marine Science Symposium, Anchorage	307.0	2	14	195.0	3,344.0
Mote Marine Symposium, Sarasota	400.0	2	12	142.0	2,504.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$7,812.0

FY15

Program Title:
Team Leader:

FORM 3B
PERSONNEL & TRAVEL DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Publication charges for scientific papers, page charges and color page charges	2,000.0
Tuition for graduate student	19,086
Long distance telephone, photocopying, printer cartridges etc.	200.0
Commodities Total	$21,286.5

FY15

Program Title:
Team Leader:

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY16

Program Title:
Team Leader:

FORM 3B
EQUIPMENT DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Trevor A. Branch	Assistant Professor	1.0	12127.9		12,127.9
To be arranged	Research Assistant	12.0	2218.2		26,618.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	14346.2	0.0	
				Personnel Total	$38,746.7

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Travel Seattle to Cordova, annual PI meeting	307.0	2	6	225.0	1,964.0
Marine Science Symposium	307.0	2	14	195.0	3,344.0
AFS meeting, venue to be arranged	400.0	2	12	200.0	3,200.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$8,508.0

FY16

Program Title:
Team Leader:

FORM 3B
PERSONNEL & TRAVEL DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Publication charges for scientific papers, page charges and color page charges	2,000.0
Tuition for graduate student	19,850.0
Long distance telephone, photocopying, printer cartridges etc.	200.0
Commodities Total	$22,050.0

FY16

Program Title:
Team Leader:

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 12-FY16

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY16

Program Title:
Team Leader:

FORM 3B
EQUIPMENT DETAIL