NOAA Technical Memorandum NMFS-NWFSC-131

Small Investments with Big Payoffs:

A Decade of the Internal Grants Program at the Northwest Fisheries Science Center

doi:10.7289/V5/TM-NWFSC-131

June 2016

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center

NOAA Technical Memorandum
NMFS-NWFSC Series

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Reference this document as follows:

Waples, R. S. 2016. Small investments with big payoffs: a decade of the Internal Grants Program at the Northwest Fisheries Science Center, U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-131, 80 p. doi:10.7289/V5/TM-NWFSC-131.

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Table of Contents

Preface v

Executive Summary vii

Introduction 1

Program Objectives 2

How Does the IGP Work? 3

- Application Process 3
- Eligibility 6
- The Review Process 7
  - Proposal Reviews 7
  - Review Panel Membership 8
  - Benefits of Serving on the IGP Review Panel 8
- Mentoring Program 9
- Vital Statistics 10
- Source of Funds 11

Assessment of Program Performance 12

- Quantitative Metrics 12
- National Recognition 14
- Management Applications 15
- Survey 16

Challenges 19

Relationship to Existing Programs 21

A Modest Proposal 22

Acknowledgments 23

Appendices 25

Preface

The Internal Grants Program (IGP) at the Northwest Fisheries Science Center (NWFSC) is unusual (perhaps unique) within federal agencies in that it allocates substantial resources (an average of over $200,000/year for a decade) for a competitive grants program to fund innovative research projects by Center scientists. The program came about as the result of a confluence of both bottom-up and top-down forces: strong pressure from rank-and-file scientists for more opportunities to pursue promising research directions and strong leadership at the Center management level.

For many decades beginning in the 1920s, the NWFSC and its predecessors included on its staff many of the top fishery biologists in the agency. By the time the IGP was initiated (the first awards were made in 2001), the Center had also amassed an impressive array of mostly younger scientists gleaned from top academic programs around the country. Most could have taken academic jobs but were interested in working someplace where the research they did could make a more direct impact on aquatic biodiversity and society as a whole. Our agency, the National Marine Fisheries Service (NMFS), routinely wrestles with very challenging problems related to stewardship of marine and anadromous species, and NMFS also places a high priority on highly-credible scientific information to provide a sound basis for managers to make policy decisions. As a consequence, our Center was increasingly seen as an attractive place to work.

About that time, a full professor at a major university came to our Center for a job interview, and I asked him why he wanted to leave a tenured position to come to our Center. “Because you have more top scientists than we do in our entire Biology Department” was the reply, and after a bit of reflection I concluded that he was right. This cadre of bright young people at the NWFSC had plenty of new ideas that could not easily be accommodated within the traditional, top-down framework for allocating funding that characterizes most government agencies. Federal scientists are excluded from competing as Principal Investigators for many research grants, such as those from the National Science Foundation, and generally tighter research budgets constrain opportunities in the programs NWFSC scientists are eligible to compete for. Center scientists therefore pressed for more opportunities for innovative research and a more transparent and merit-based approach to allocating research funds.

During the period 1994-2010, the NWFSC had a strong and innovative leader in its Center Director, Dr. Usha Varanasi. Usha was not afraid to take risks or make bold decisions, and in the fall of 2000 she called several of the most senior staff into her office and directed us to develop what became the Internal Grants Program, which ran for a decade until dwindling budgets forced its suspension after 2011. I was fortunate enough to be appointed Director of the IGP during that decade, except for a sabbatical year in 2003-2004 when Vera Trainer and Jeff Hard ably managed the helm. The report that follows summarizes a decade of accomplishments of the Center's IGP.

Robin Waples
Seattle, Washington
September 2014

Executive Summary

In 2000, the Northwest Fisheries Science Center (NWFSC) in Seattle, Washington, part of the National Marine Fisheries Service (NMFS), initiated a bold new competitive program to provide seed money for cutting-edge research by Center scientists. This Internal Grants Program (IGP) had multiple objectives, including: advance professional development of junior scientists; re-invigorate more senior scientists whose research careers had stagnated; promote effective grant-writing skills; promote a diverse array of research projects; and promote interdisciplinary and inter-divisional research collaborations. The Center appointed a Review Panel to oversee the program, manage the peer-review process, and make funding recommendations. From 2001 to 2011, the IGP made 73 awards to 59 different Principal Investigators, for a mean of $220K/year. Awards were for 1- or 2-year projects with budgets that ranged from $3K to $95K (median $29K). Success rate for proposals submitted through the Open Track was 33% compared to 43% for those submitted through the Junior Track, which targeted less-experienced scientists. Winning proposals covered a wide range of topics, organisms, and methodologies; many involved collaborations among different divisions within the Center or with other scientists from outside the Center.

Tangible products from IGP-funded research document just how good an investment this seed money was. The total amount awarded over the decade ($2.4M) has produced over $21M in new grants based at least in part on results from IGP projects – a nearly 9-fold multiplier effect on the original investment. The winning projects have produced well over 100 peer-reviewed publications and over 250 scientific presentations to date, with more added on a continual basis. Information developed by IGP-funded projects has been used extensively by managers to improve estimates of population abundance and to advance conservation and recovery of threatened and endangered species. An anonymous survey of Center staff also documented substantial, albeit less tangible, benefits that accrued from the IGP, including a large boost to staff morale, opportunities for junior scientists to take the lead for the first time on a research project, and the chance to explore promising new ideas unlikely to be funded through traditional channels. The 34 Center scientists who served on the IGP Review Panel were able to experience the peer-review process from a different perspective and gained an appreciation for the diversity of research conducted within the NWFSC. In 2004, the U.S. Department of Commerce singled out the Center's IGP as an outstanding example of an innovative and cost-effective way to address a key theme in the President's Management Agenda: Strategic Management of Human Capital.

The NWFSC's IGP differs in several important ways from about a dozen other competitive programs that NMFS administers each year. These national programs address important core, mission-related needs and generally target very specific themes (e.g., ocean acoustics, sea turtle assessments) that narrowly define the range of proposals that will be considered. Many awards are for relatively large projects ($100K – $200K), and they often go to senior researchers. These national programs vary widely in how clear the selection criteria are and how transparent the evaluation process is. By awarding small amounts of seed money for promising new ideas, by encouraging participation and career development by more junior scientists, and by having a competitive and transparent peer-review process, the NWFSC's IGP provides a cost-effective way to complement these national programs. For a little over $1M per year, something like the IGP could be replicated at each of the NMFS Science Centers, and it is hard to imagine an investment that would pay higher overall dividends.

Introduction

Governments, like many organizations, typically operate in a top-down fashion, and this is particularly true with respect to finances. Money flows in at the top, is distributed initially at the highest hierarchical levels according to established priorities and mandates, and subsequently trickles down to mid-level managers before reaching the operational level of an individual project. Although this system has some obvious advantages, few would claim that it is the optimal way to foster creativity. This presents a challenge for government agencies that generate and use scientific information, because creativity and out-of-the-box thinking are hallmarks of the scientific method.

This report documents results of a decade-long program within a government agency that provided an alternative to this top-down funding process. In the fall of 2000, the Northwest Fisheries Science Center (NWFSC) in Seattle, WA, part of the National Marine Fisheries Service (NMFS), initiated a bold new program to provide seed money for cutting-edge research by Center scientists. In this Internal Grants Program (IGP), awards were competitive and made primarily on the basis of scientific merit and originality. That did not mean that any idea was potentially fundable; for example, no IGP funds were spent on projects to study the sex lives of anteaters, the behavior of gerbils in space flight, or the many micro-environments in an alfalfa field in Kansas. Important as these topics might be, they don’t fall under the purview of issues that are relevant to NMFS and its parent agency, the National Oceanic and Atmospheric Administration (NOAA), nor would they be considered allowable uses of funds appropriated by Congress for specific purposes. A requirement for consideration for IGP funding was that the proposed research be broadly relevant to NOAA’s stewardship responsibility for living marine resources, as well as to more specific elements of the Center’s Research Plan (see https://www.nwfsc.noaa.gov/about/planning/index.cfm). Nevertheless, that left a lot of room for innovative ideas and creative thinking.

This report documents 10 years (2001-2011) of the IGP at the NWFSC. During that time, the IGP distributed over $2M in awards, to almost 60 different scientists, for projects covering a wide range of topics and organisms. Information presented in this report shows that the IGP was successful in meeting its varied objectives (which are detailed in the next section). For example, IGP seed money generated almost nine times as much in spin-off grants, as well as a large number of tangible products such as peer-reviewed publications and scientific presentations. The program also boosted staff morale and substantially contributed to career development, especially for junior scientists. A number of IGP-funded projects have produced information that has directly affected management decisions by NMFS and the broader scientific community.

In 2012, faced with a sharply eroding budget, the Center suspended the IGP. This hiatus provided an opportune time to take stock of the program, review what it has accomplished, and identify challenges that remain. This report provides empirical information that can be used to make informed decisions about the future of the IGP or similar programs. For a relatively small investment, programs like this could be replicated at all NMFS Science Centers.

Program Objectives

As discussed in the Preface, the IGP was initiated in response to requests by Center staff for more opportunities to pursue promising lines of research that would be evaluated based on their scientific merit. Although the primary goal of the IGP was to provide seed money for high-quality research by Center scientists, particularly for projects not likely to attract initial funding from other sources, the program also had a number of other important objectives, including the following:

- Advance professional development of junior scientists
- Re-invigorate research careers of more senior scientists
- Promote effective grant-writing skills
- Promote a diverse array of research projects
- Promote interdisciplinary and inter-divisional research collaborations

Balancing these diverse objectives at times was difficult, as is discussed below under "Challenges."

How Does the IGP Work?

Application Process

Each year, the competition is initiated when the IGP Director sends a message to all staff announcing details of the program for the current fiscal year. To help kick off a new competition, the Director generally organizes a half-day program featuring talks by previous winners about their funded research, tips about preparing competitive proposals, and a general Q&A session. The application process is loosely modeled on national competitive grants programs (e.g., National Science Foundation, National Institutes of Health, Sea Grant). Applicants are required to submit a short pre-proposal by a specified date, generally about 6 weeks before the deadline for final proposals. No applications are screened out at this stage; instead, the pre-proposals are used for the following purposes:

- To ensure that full proposals reflect serious consideration and are not just ideas thrown together at the last minute.
- To give the Director of the IGP an early indication of how many full proposals to expect, so additional members of the IGP Review Panel (see below for details) can be recruited if necessary.
- To allow supervisors a chance to review background data used for the eligibility criteria to make sure they are accurate.
- To allow supervisors a chance to review the characterization of the roles of Principal Investigators (PIs) and collaborators to ensure they are reasonable.
- To provide managers early information about proposed research to allow better planning of resources and staffing. If the proposed research might create staffing problems, early identification of the issues should improve the chances of a satisfactory resolution before the final proposal is due.
- To identify applicants who might benefit from mentoring during preparation of the final proposal.
- To ensure that the goals and objectives of the proposals are good fits to the Center's Research Plan and the agency's mission.

The IGP "Guidelines for Final Proposals" (see Appendix G) identifies required elements for the proposal and maximum lengths for each section.

Initially, the IGP had a single track for all applicants and an average of about $200K in new money awarded each year (Fig. 1). The second year of 2-year projects funded the previous year generally consumed some fraction of the new funds, so on average about $150K was available for new awards for the current year. In 2005, encouraged by the success of the first 4 years of the program, the Center's management team doubled the amount of new money, to $400K. The new two-track (Open and Junior) system enhanced the ability of the IGP to meet its objective of providing career development for junior scientists. The $400K allocation proved not to be sustainable and was reduced to between $200K and $300K in subsequent years, but the two-track system was retained. Applicants meeting the criteria for Junior Track (see next section) were considered in that track; others were placed in the Open Track.

In years when the Center leadership determined a fixed maximum total for new awards, the Panel put together a recommended list of proposals that fit within this cap; if some other proposals are closely ranked, the Review Panel might identify them as candidates for funding provided that the Center budget allows more awards than expected. If the amount that the Center could allocate to the IGP in the current year was uncertain at the time the Review Panel met, the Panel prepared a prioritized list of proposals whose total budgets spanned the likely range of allocations. Panel recommendations regarding IGP funding were communicated to the Center Director in a memorandum. Although final decisions about IGP funding were made by the Center Director, in practice the allocations always followed the Panel recommendations, within the constraints of the total amount of funding available.

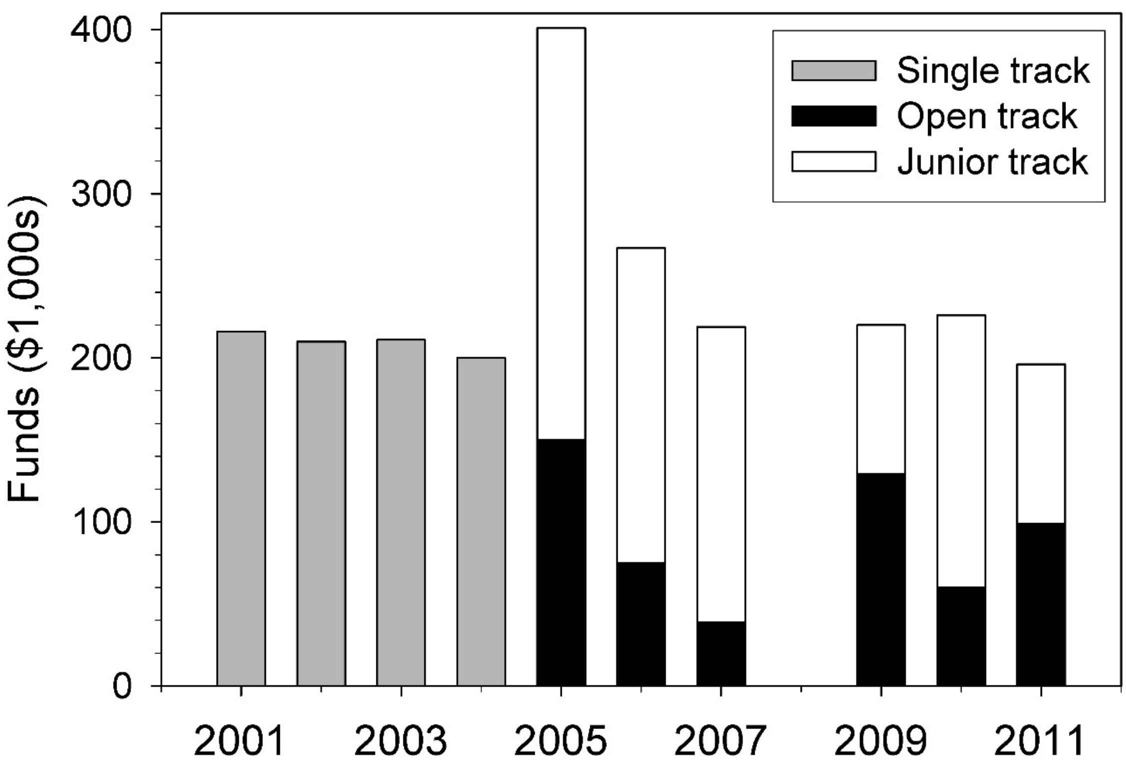

Figure 1. Annual funding levels. Values include allocations for the first year of new projects and the second year of 2-year projects. A single track was used 2001-2004; in 2005, funding was temporarily doubled along with creation of separate Junior and Open tracks. In 2008, a competition was held and the Panel produced a prioritized list of recommended winners, but no funds were available. The top five proposals from 2008 were funded in 2009, and a separate competition was not held that year.

Many IGP-funded projects involve seasonal fieldwork that requires considerable advance planning and must be conducted within specific time windows. Frequently, these and other projects also involve contracting for various types of services, and these contracts must be initiated before a variety of fixed deadlines throughout the fiscal year. Therefore, in an ideal world, to maximize the amount of time to spend the money in the most efficient and productive way possible, the annual IGP competition would be held as early as possible in the federal fiscal year (which starts October 1). In reality, during the decade the IGP operated, the NWFSC rarely knew how much funding it would receive from NMFS until late spring or summer. As a compromise, the sequence of events typically went something like this:

- Announcement of a new IGP competition in October
- Pre-proposals due in early to mid-December
- Final proposals due in mid- to late-January
- Reviews conducted over next 4-6 weeks
- Panel meets in March to develop recommendations

In good years, funds were distributed in early April, before most fieldwork began. In uncertain budget years, funds were never allocated or were allocated very late in the fiscal year (June or July).

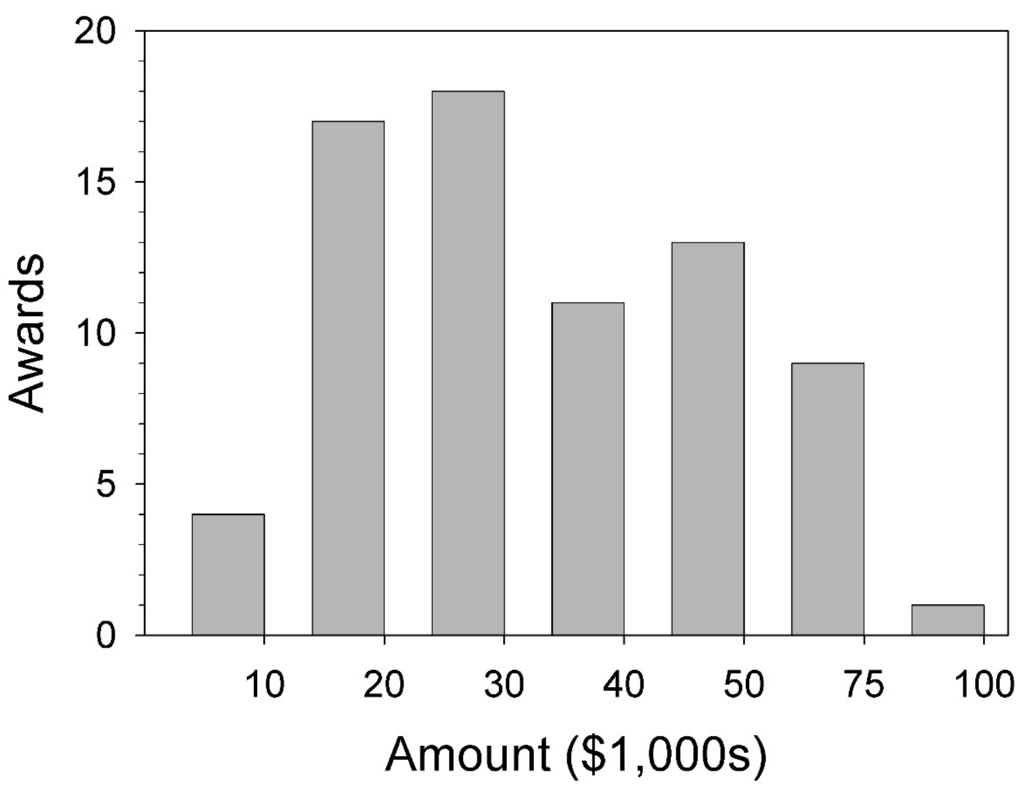

Figure 2. Size of individual awards. Award amounts include both years for 2-year projects. Note that the last two bins on the right span a greater range of award amounts.

Eligibility

The IGP is open to all permanent or term employees of the NWFSC. Eligibility for the Junior Track depends in part on the pay level of the employee. During the course of the IGP, the NWFSC switched from the old GS 1-15 system to the Commerce Alternative Personnel System (CAPS) having five Paybands (ZP-I-V), with equivalencies as follows: ZP-V = GS 15; ZP-IV = GS 13/14; ZP-III = GS 11/12; ZP-II = GS 7-10; ZP-I = GS 1-6. Center scientists eligible for consideration under the Junior Track can fall in either of two categories:

1) Pay Bands 1 and 2, and Pay Band 3, Step 1, regardless of longevity[1];
2) Pay Band 3, Step 2, or higher, who a) are within 10 years of receiving their most advanced degree, **AND** b) have been employed at the Center less than 5 years[2].

If a proposal has multiple PIs, all must meet the Junior Track criteria for the proposal to be considered in that track. Scientists who receive 2 years of funding through the Junior Track (one 2-year proposal or two 1-year proposals) move up to the Open Track for all subsequent competitions.

The Open Track is available to all NOAA permanent or term employees, but special consideration is given to a) those for whom the award would provide a significant opportunity for career development, or b) those who are submitting a novel research idea not likely to be funded elsewhere. It should be kept in mind that a major goal of the IGP is to promote career development of senior (as well as junior) scientists. For Open Track applicants, this means that the Panel looked for evidence that the PI is intimately involved in all major aspects of the project and is not just a manager of the research. It is recognized, however, that in some cases a significant fraction of fieldwork, data collection, etc., will be performed by technical staff, who might be Center employees, contract workers, interns, etc. Many proposals involve substantial collaborations with other scientists inside or outside the Center, and this is perfectly acceptable under the IGP guidelines. However, the PI should be the scientific lead for the project and the one who will be conducting or directly overseeing the work Proposals can identify as collaborators individuals who are expected to make substantial contributions to the project, and the number or status of collaborators does not affect eligibility requirements.

Scientists who have received two consecutive years of funding (two 1-year projects or one 2-year project) must wait a year before applying again. All award recipients must complete a report summarizing results of their funded research, and they are not eligible to apply for subsequent competitions until reports for prior awards are submitted.

[1] Prior to adoption of the CAPS system, this criterion was GS-11 or below
[2] Prior to adoption of the CAPS system, this criterion was GS-12 or above

The Review Process

Proposal Reviews

Reviews are conducted and managed by the IGP Review Panel, Chaired by the IGP Director. Panel members are Center scientists who serve rotating terms, typically for 3 years. After receipt of the final proposals, the Director assigns them to Panel members, taking into consideration subject-matter expertise and potential conflicts of interest. Each proposal is reviewed by three panel members, designated as the Lead, Expert, and Reviewer members. The Reviewer member simply provides a written review. In addition to providing a review, the Expert member secures a peer review from a qualified person outside the NWFSC. The Lead member provides a review, collates the four total reviews, summarizes them at the Review Panel Meeting, and writes a short summary of the Panel's decision that is included in the package sent to the applicant.

Panel members complete an internal proposal evaluation form for each proposal they evaluate. This form has four sections that evaluate 1) the importance of the research question, 2) scientific quality and originality, 3) congruence with IGP objectives, and 4) scientific productivity of the PI(s) (see Appendix G). The first, third, and fourth sections are each worth a maximum of 5 points, and the second is worth twice that, leading to a maximum total score of 25 points. After some experimentation, the IGP settled on a modified form for external reviewers, who were asked to evaluate only the first two sections: importance of question (10 points maximum) and scientific quality and originality (15 points maximum). This resulted in the same maximum total score of 25 points but did not require the external reviewer to evaluate sections 3 and 4, which are difficult to assess without detailed knowledge of the context and research situation of the PI(s) within the NWFSC.

When all reviews are competed, the IGP Director tabulates results for discussion at the Review Panel meeting. Numerical scores from the four reviewers are used as a starting point for developing overall rankings. Other important factors include opportunities for career development (preference generally given to more junior applicants), cost (a very expensive proposal will generally have a higher standard to meet), diversity of topics and research groups, and whether the PI had received any IGP awards in the past. Scores on the Scientific Quality component of the proposal are an important factor in helping to decide between closely-ranked proposals. Separate pools of money were not allocated for Junior and Open Track awards; instead, Junior and Open Track proposals were ranked separately and subsequently merged to produce a single prioritized ranking. All else being equal, a Junior Track proposal generally received preference over a closely ranked Open Track proposal. However, the Review Panel did not recommend for funding any proposals from either track that, in their view, did not represent high-quality science that was high priority with respect to the current NWFSC Research Plan.

Review Panel Membership

A total of 34 Center scientists served on the IGP Review Panel over the 10-year period (see Acknowledgments for a list of all Panel members). Most served staggered 3-year terms, with the IGP Director serving as Chair and providing continuity across all years. The nature and makeup of the Panel evolved over time in an interesting way. Although the program itself represented a major shift from standard ways of doing things, initial implementation of the Panel still reflected a paternalistic, top-down approach. In the first year, all panel members were either Division Directors or the most senior Program Managers in the Center (GS 14-15); this reflected the belief that, by virtue of their long experience, these people were in the best position to provide oversight and make sure that the program did not somehow go off the rails. In the second year, we became a bit more adventurous and invited one junior scientist onto the Panel, with the understanding that this "junior" position would rotate among eligible staff. Before long, we realized that these less-senior members contributed greatly to the functions of the Review Panel; by the second half of the decade, the typical Panel member was an early- to mid-career scientist, with experience in leading projects of their own and an interest in learning more about other research programs at the Center. Most, but not all, panel members had Ph.D.s; many were previous winners of IGP awards who wanted to contribute to the program that had enriched their careers at the Center.

Without exception, Review Panel members were dedicated and hard-working and took their responsibilities seriously. Most had recently led or been involved with projects similar to those being proposed for funding, so they were familiar with the challenges faced by scientists trying to do cutting-edge research on modest budgets; for this reason, they were also more likely to anticipate practical difficulties and to spot places where PIs were glossing over important details.

Benefits of Serving on the IGP Review Panel

An informal survey of Review Panel members indicated several benefits of service on the panel, including the ability to develop professionally as a reviewer (which is a large part of contributing to the larger scientific community) and the ability to sharpen grant-writing skills (by sitting on the other side of the table in the review process). Perhaps the most important benefit was the opportunity to see up close the full range of fascinating research conducted at the Center. Scientists tend to focus narrowly on their own specialties, particularly in natural resource agencies like NOAA where workloads are often driven by a series of crises (such as an oil spill or a petition to list an endangered species). Furthermore, the hierarchical structure inherent in most government institutions tends to inhibit cross-fertilization and collaborations across disciplines. Some of the more senior scientists at the Center have experienced similar benefits (enhanced internal communication about research among junior and senior scientists) when serving on grant panels outside of NOAA (e.g., National Science Foundation, U.S. Department of Agriculture).

Mentoring Program

The IGP Mentoring Program was established to partner novice grant writers or other interested staff seeking grant-writing assistance with a mentor having experience in writing successful grant proposals. Mentors were chosen from a list of volunteers from each Division at the NWFSC, recruited by the Internal Grants Mentorship Program Committee and representing the broad scientific specialties at the Center. Scientists planning to submit a grant application could choose to work with a mentor inside or outside their Division; the latter option was particularly useful to promote cross-division collaboration. Applicants could ask mentors for assistance with pre-proposals or full proposals and were encouraged to contact mentors at least 2 weeks in advance of proposal deadlines to ensure adequate time for incorporating suggestions into the proposals. If mentees were not certain which mentor was the best match for them, they could contact the IGP Director or the leader of the Mentoring Program for assistance with making an effective match.

The success of the Mentorship Program is illustrated by the number of investigators who were funded after participating in the program. These included proposals from junior staff that had at least one previous unsuccessful proposal that was subsequently funded on the second try after incorporating changes and advice from a mentor. To take one example, Vera Trainer, leader of the IGP Mentoring Program and a mentor for the program, advised a junior staff member with a proposal idea outside her specific area of expertise. This person had made one unsuccessful attempt at seeking funding through the IGP. Working in close collaboration with his supervisor, Vera helped with the proposal writing, paying close attention to program deadlines. His resubmitted proposal was funded and became the basis of his Master’s thesis. This learning experience made him a better writer, a more confident scientist, and a more valuable contributor to NOAA’s mission.

Table 1. Summary information for the Northwest Fisheries Science Center’s Internal Grants Program, 2001-2011.

Number of awards	73
Number of different lead PIs	59
Amount funded	$2.4M (3K–95K)
Grade level of winners	GS 9–14*
Years at NWFSC	1–20+
Collaborators	0 - many
Organisms	bacteria – sturgeon
Number of review panelists	34

* Or equivalent in the Commerce Alternative Personnel System

Vital Statistics

Over the period 2001-2011, the Center gave 73 IGP awards to 59 different PIs (Table 1), with eight PIs winning two different awards and three winning three. The total amount awarded was $2.4 million; most funded projects were between $10K and $50K (Fig. 2), but they ranged from $3K to $95K. Allocations in most years were close to $200K and averaged about $220K, including one year with $400K and another year with no awards given (Fig. 1). Most (63%) of the awards were for a single year, with the remainder going to 2-year projects. The number of applicants per year ranged from 11 (2002) to 27 (2006) (Table 2), and the overall success rate ranged from 26% (2008) to 64% (2002). Across all years, Junior Track applicants enjoyed a 43% success rate, whereas one-third of Open Track applicants were successful. Not all winners received the full funding that they requested.

Table 2. Number of applicants and number of grants awarded, by year and track. A separate Junior Track was not established until 2005.

	Open			Junior		
Year	Awards	Applicants	Percent successful	Awards	Applicants	Percent successful
2001	8	16	50.0	-	-	-
2002	7	11	63.6	-	-	-
2003	5	24	20.8	-	-	-
2004	6	26	23.1	-	-	-
2005	5	8	62.5	9	16	56.3
2006	2	9	22.2	6	18	33.3
2007	2	6	33.3	5	11	45.5
2009	3	10	30.0	2	9	22.2
2010	2	14	14.3	5	10	50.0
2011	3	6	50.0	3	6	50.0
Totals	43	130	33.1	30	70	42.9

The winning proposals covered a wide range of taxa and themes. Each of the following topics was the subject of at least one winning proposal: brain development in hatchery salmon; olfactory imprinting; transmission of bacterial kidney disease; non-native species; physiological indicators of growth and maturation; development and use of large-scale genomics technologies; extracting ancient DNA from old fish scales; effects of dam removal; evaluating effectiveness of habitat restoration; use of acoustic tags to track sturgeon and flatfish; avian predation on juvenile salmon; biomarkers for fish affected by oil spills; effects of domoic acid on salmon and killer whales; forensic analysis for species identification; development of risk-assessment software; importance of marine-derived nutrients for freshwater ecosystems; using stable isotopes to study rockfish feeding; genetic markers for harmful algal blooms; a DNA repository for deep-sea corals; tracking effects of marine protected areas; promoting marine conservation in high school curricula; importance of habitat connectivity; chemical contaminants in sixgill sharks; novel methods for recapturing aquaculture escapes; movement patterns of jellyfish; community profiling of bacteria near sewage outfalls; developing plant-based proteins for aquaculture feed. Please see Appendix A for a full list of winning proposals.

Source of Funds

The IGP was initiated using seed money from the Center Director's budget, in a fashion similar to what was used to kick-start other important Center programs [e.g., the Estuarine and Ocean Ecology Program (http://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/index.cfm) and the Monster Seminar Jam (http://www.nwfsc.noaa.gov/news/events/weekly_seminars/index.cfm)]. As the IGP grew in popularity and demonstrated its effectiveness, a more permanent source of funding was developed by tapping into training funds allocated to the Center Director's office and to each of the five research Divisions of the NWFSC. The strong emphasis of the IGP on career development and improving the research and grant-writing skills of younger scientists met the goals of the training funds.

Table 3. A brief summary of tangible products from winning proposals. For more details, see Appendices A-G.

Total amount awarded	$2.4M
Spin-off grants	39 ($21.5M)
Peer-reviewed publications	> 110
Reports and other publications	> 35
Scientific presentations	> 250

Table 4. Years since last degree for winning PIs, calculated at time of grant application.

Years	Junior track	Open track
0-3	4	8
4-6	10	6
7-10	11	10
11-20	4	15
>20	1	3

Assessment of Program Performance

Quantitative Metrics

A variety of quantitative metrics document impacta of the IGP. Perhaps the most important metric of scientific productivity is peer-reviewed publications. As of September 2014, the 73 awards made from 2001 to 2011 had produced over 110 peer-reviewed publications that appeared in a wide range of journals and books (Table 3; see full list in Appendix C)—an average of about 1.5 per award. Because the lag time between conducting research and publication can be substantial, these numbers are continually growing, especially for awards made in the later years of the program. Tangible products of the IGP program also include over 250 scientific presentations related to funded research (Appendix D), as well as numerous reports and other publications and miscellaneous other products (Appendix E).

Although these productivity metrics are impressive, perhaps the most dramatic evidence for success of the IGP is the nearly 9-fold multiplier effect of the initial seed money for IGP projects. Collectively, PIs used results obtained from the $2.4M in funds awarded over a decade to generate more than $21M in new funding for Center research (Appendix B). Researchers, especially more junior ones, often find themselves in the classic "Catch-22" of grants funding: they must show preliminary results to get an outside grant, but don't have the resources to develop the preliminary results. The success of IGP winners in securing follow-up and spin-off grants demonstrates the importance of having a program like the IGP that gives researchers a chance to demonstrate proof-of-concept for promising new ideas.

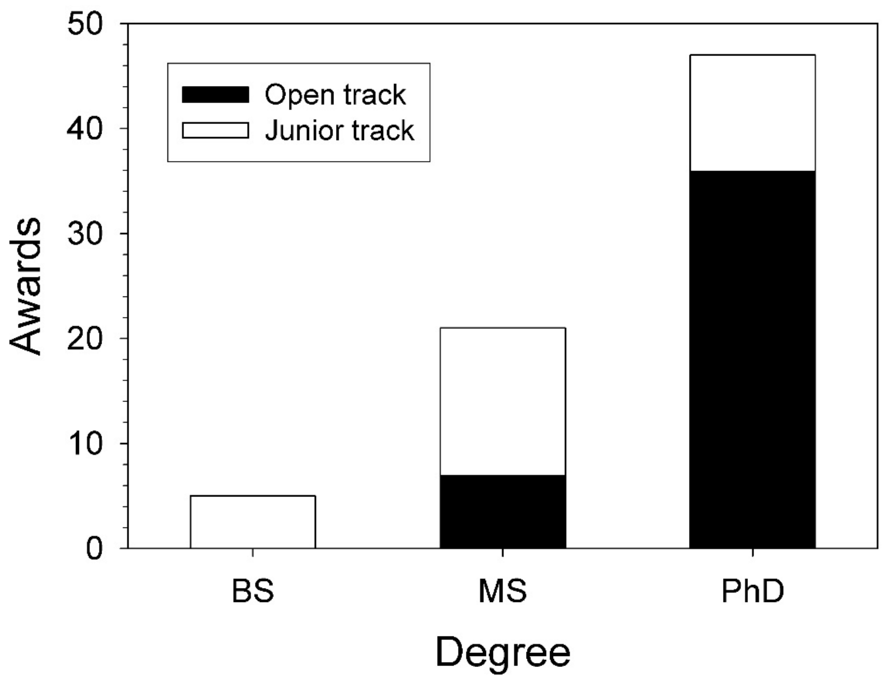

Figure 3. Highest degree obtained by lead Principal Investigators for winning proposals.

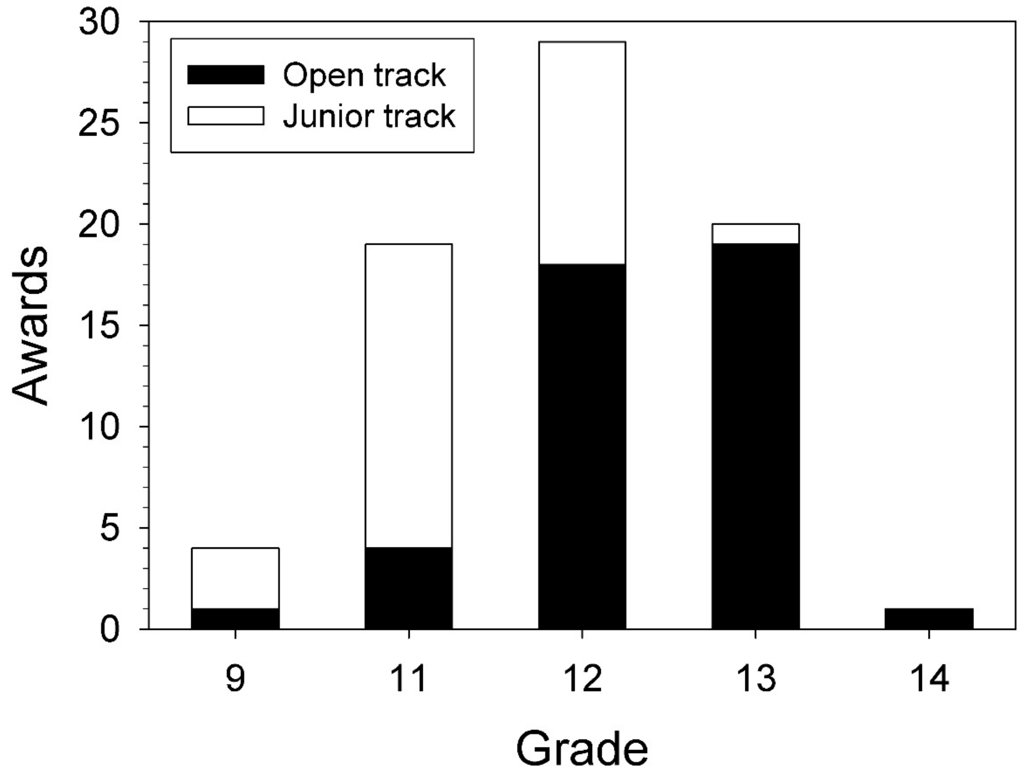

Figure 4. Distribution of awards by the pay grade of the lead Principal Investigator. For later years, the grade was converted from the comparable classification in the Commerce Alternative Personnel System.

Establishing a separate Junior Track in 2004 clearly helped to achieve the dual goals of promoting diversity among IGP winners and advancing careers of junior scientists. Whereas 36 of 43 Open Track winners (84%) had received Ph.D.s at the time of application, nearly half of the Junior Track awards went to scientists who only had a Master's degree, and 17% went to those with only a Bachelor's degree (Fig. 3). Similarly, most Open Track awards went to scientists at the GS-12 level or above, while the majority of Junior Track awards went to those in GS 9-11 positions (Fig. 4). Almost half the Junior Track winners had been at the NWFSC for 6 years or less at the time of application, while 43% of Open Track winners had been employed at the NWFSC for > 10 years (Table 4). This latter statistic suggests that the IGP was at least partially successful in helping to re-invigorate the research careers of more senior researchers. The percentage of female applicants each year ranged from just under 20% to 50%, with no apparent trend over time (Fig. 5). Across all years, females represented 37% of the applicants and 43% of the winners, which indicates that female applicants had a slightly higher probability of winning an award than did male applicants.

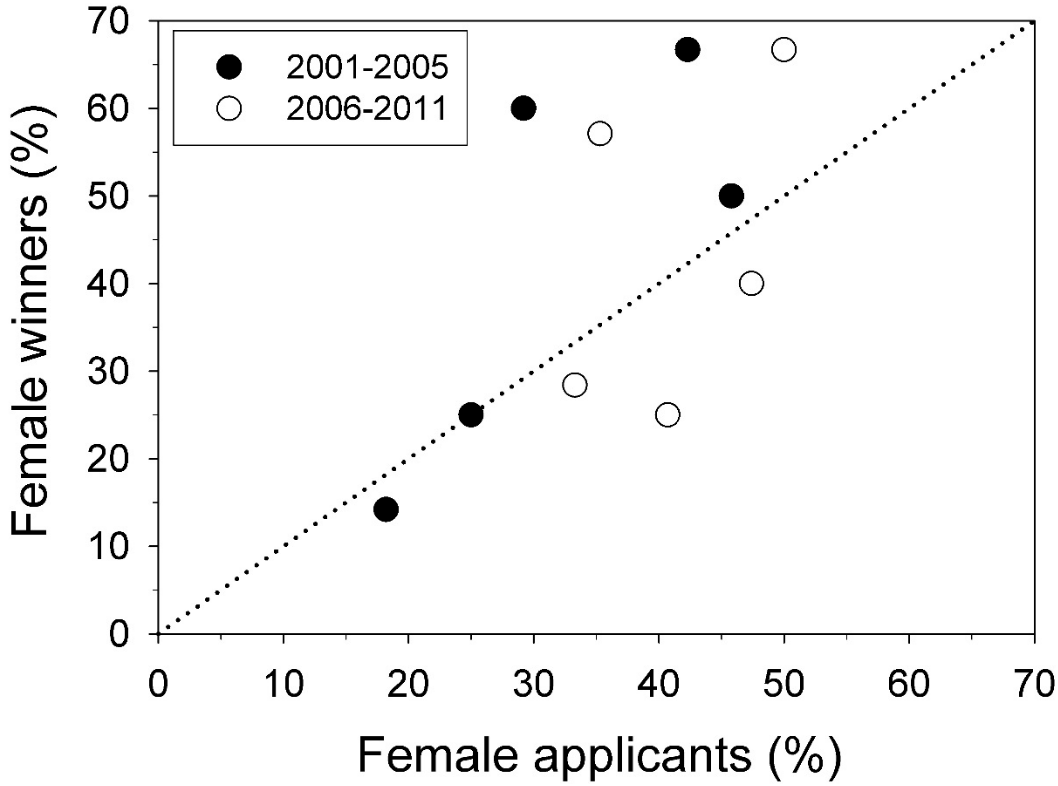

Figure 5. Percentage of winning Principal Investigators that were female compared to the percentage of all applicants that were female. Points above the line indicate years in which the percentage of female winners exceeded the percentage of female applicants.

National Recognition

The goals of the IGP are well aligned with the President's Management Agenda, an initiative announced by President George W. Bush in 2001 to improve efficiency and effectiveness of the federal government. In 2004, the U.S. Department of Commerce[3] singled out the Center's IGP as an outstanding example of an innovative and cost-effective way to address a central theme of the Agenda, Strategic Management of Human Capital.

[3] U.S. Department of Commerce, Fiscal Year 2004 Performance and Accountability Report to the Office of Personnel Management; available at http://www.osec.doc.gov/bmi/budget/FY04PAR.htm.

Management Applications

Results of IGP-funded research have helped to address many real-world problems in conservation and management (see Appendix F), and a few of these are worth noting here. One of the initial (2001) grants went to Nat Scholz and John Incardona to establish a breeding and imaging facility for the zebrafish (*Danio rerio*), which was the third vertebrate genome (after humans and mice) to be sequenced in its entirety and has become a major new model system. Scholz, Incardona, and colleagues took advantage of a sophisticated toolbox developed in biomedical research to better understand impacts of coastal and ocean pollution on living marine resources, particularly fish. Following their IGP award, they published more than 20 peer-reviewed studies on zebrafish, secured more than $1M in new funding, and forged new partnerships with multiple universities. The zebrafish model has served as a platform for several influential discoveries, including effects of oil on the developing zebrafish heart that guided NOAA's natural resource injury assessment in the aftermath of two major oil spills (*Cosco Busan* and *Deepwater Horizon*). Their zebrafish research also revealed unanticipated synergistic interactions between widely-used pesticides—a topic that has been a major source of uncertainty for federal ESA consultations between NOAA and the Environmental Protection Agency, as well as the focus of a recent review by the National Academy of Sciences.

Brian Beckman won a 2003 award for a project to conduct controlled laboratory experiments to test the idea that a simple blood test could provide information about growth rate of fish in the ocean—a key variable that is difficult to measure. IGP-funded experiments demonstrated that levels of the hormone insulin-like growth factor 1 (IGF1) were positively and significantly related to growth, and results were robust to a number of potentially confounding factors. Subsequently, blood samples taken from juvenile salmon during ocean surveys demonstrated significant inter-annual variation in growth, and this variation was positively correlated with adult returns of salmon 2 years later. As a result of this research, plasma IGF1 measures are being incorporated with other oceanographic indices to provide integrated ecosystem assessments and forecasts of adult abundance. These are used by NOAA managers to determine whether proposed actions are likely to jeopardize populations listed under the federal ESA and are also likely to improve forecasts of adult salmon returns.

Mary Moser used three separate Internal Grants awards (between 2003 and 2010) to support acoustic telemetry investigations of threatened green sturgeon (*Acipenser medirostris*) in coastal bays of Washington state. Each project had specific research goals and resulting scientific products (see Appendices C,D,E for details). Data on the distribution of sturgeon and timing and extent of movements throughout large geographic areas have been used extensively by NOAA to guide management decisions under the ESA. IGP-generated information for green sturgeon has been crucial in addressing the following questions: a) How large are the Distinct Population Segments that can be considered for listing under the ESA? b) What is the extent of Critical Habitat for this species? and c) What actions will promote ESA recovery of green sturgeon? At least in part as a result of data obtained in these studies, green sturgeon habitat has been protected, harvest of green sturgeon has been limited, and use of insecticides to control green sturgeon food resources (burrowing shrimp) has been eliminated. In addition, these studies have been used as a template for acoustic monitoring of ESA-listed shortnose and Atlantic sturgeons on the East Coast and have provided information needed for development of safe-handling and tagging protocols for all ESA-listed sturgeons.

In a project funded by the IGP in 2005, Tom Good studied the extent of predation by Caspian terns on threatened and endangered juvenile Pacific salmon. He conducted detailed observational studies on tern foraging and diet and recovering passive-integrated-responder (PIT) tags from breeding colonies located in the Potholes Reservoir in eastern Washington. PIT tags, which are about the size of a grain of rice and contain a passive computer chip that "responds" to a pulse of energy by sending its unique code, are routinely applied to many thousands of young salmon and steelhead each year. Birds that prey on juvenile salmon eventually deposit large numbers of PIT tags in and around their nests. Over the course of two breeding seasons, Good and colleagues determined that: 1) predation on juvenile Pacific salmon was not as extensive as it was for tern colonies in the lower Columbia River; but b) mortality was nevertheless non-trivial and disproportionately affected steelhead, with effects being particularly large for the ESA-listed population migrating from the Upper Columbia River. This study was foundational in the region and paved the way for follow-up studies that led to preparation of an Inland Avian Predation Management Plan by the US Army Corps of Engineers (http://www.nww.usace.army.mil/Missions/Projects/InlandAvianPredationManagementPlan.aspx). This IGP-funded research provided a science-based way for the agency to respond to a mandate to comply with provisions of the Federal Columbia River Power System 2008 Biological Opinion by NMFS.

Survey

Anecdotal accounts indicated widespread support within the NWFSC for the IGP, but to quantify the views about this program we conducted an anonymous survey in 2012. Everyone at the NWFSC was given a link to the four-question, web-based survey and encouraged to complete it; a total of 45 responses were received. The first question asked about the respondent's relationship to the IGP (Table 5). As might be expected, the open solicitation did not result in a random sample from the entire Center; responses were disproportionately from individuals who had had some experience with the IGP program. Almost three-quarters of respondents had received an IGP award (and hence might be expected to respond favorably to the survey). On the other hand, over half of all respondents had been a PI or Co-PI of an application that was NOT funded. Of the 31 winners who responded to the survey, the majority (17) also submitted at least one proposal that did not win. Forty percent of respondents had been a collaborator on at least one proposal (funded or unfunded). Nine respondents had served on the IGP Review Panel, and a few apparently had little or no direct involvement with the program.

Question 2 in the survey asked for information about benefits the IGP has provided. By far the most consistently cited benefit (70% of respondents) directly aligns with one of the primary objectives of the IGP: to provide seed money for innovative research. Several other benefits were identified by roughly 25% of the respondents, including providing support for junior

Table 5. Results from an anonymous survey of attitudes toward the Northwest Fisheries Science Center's Internal Grants Program (IGP). The online questionnaire was circulated to all Center staff. The percent of responses falling into each category was calculated with respect to the number that responded to each question [as noted in brackets]. Except for Question 4, an individual's responses could fall into more than one category, so the sums can exceed 100%.

	Number	%
Question 1. Relationship to the IGP [44 responded]		
PI or co-PI of an application that was funded	32	72.7
PI or co-PI of an application that was NOT funded	22	50.0
As PI or co-PI: Both winner and loser	17	38.6
Winner only	14	31.8
Loser only	5	11.4
Collaborator on an IGP proposal	17	38.6
Served as a member of the IGP Review Panel	9	20.5
NOAA employee, never applied for an IGP award	2	4.5
Not a NOAA employee	3	6.8
Question 2. Benefits the IGP has provided [43]		
Provided seed money for innovative research	30	69.8
Supported junior scientists; provided a chance to be a PI	12	27.9
Led to spin-off or follow-up grants from other sources	9	20.9
Spawned new contacts/collaborations	9	20.9
Provided training and/or professional development	10	23.3
Positive experiences from Panel membership	3	7.0
Miscellaneous positive comments	6	14.0
Negative comments	3	7.0
Question 3. Suggestions for improvement [38]		
Ensure increased and more reliable/consistent funding	17	44.7
Solid or great program; just need more reliable funding	7	18.4
Adjust expertise or composition of the Review Panel	6	15.8
Expand items that can be covered (e.g., travel grants)	2	5.3
Miscellaneous suggestions for improvement	11	28.9
Negative comments	3	7.9
Question 4. Any other comments? [25]		
Very positive	18	72.0
Generally positive	2	8.0
Miscellaneous	3	12.0
Negative comments	2	8.0

scientists, especially the chance to lead and manage their own project. Three respondents noted positive experiences from membership on the Review Panel, and several miscellaneous benefits were noted by individual respondents (Table 5).

In response to Question 3 (suggestions for improvements), the most consistent theme (63% of respondents) was the need for more reliable and consistent funding. This reflected the reality that, as the general funding situation within NMFS and the NWFSC deteriorated during the last half of the IGP program, it became more and more difficult for the Center leadership to determine in a timely fashion whether enough funds would be available for the IGP. Even if sufficient funds eventually become available to allow funding of the program, it might be too late in the fiscal year to allocate them for the winning projects. Some of these commenters noted that they had invested considerable time and effort into preparing proposals for a competition that was never conducted or, if so, no awards were ever made. The most frequent other suggestion for improvement (15% of respondents) was to adjust the expertise or composition of the Review Panel—in particular, several suggested including more scientists with field as opposed to bench/lab experience. A number of miscellaneous suggestions were offered by one individual each (Table 5).

The open-ended Question 4 (any additional comments) elicited a number of very positive comments, such as: "I found this program to be fantastic!" "It's hard to overemphasize how important this program has been." "A great source for internal/external collaboration." "Without this program a great deal of valuable research at this Center just would not happen." "Probably one of the most productive expenditures the Center has made." "The IGP has been one of the most positive aspects of my research career at the NWFSC."

In Table 5 a few comments are identified as 'negative; these came from a total of five individuals, and based on their responses to Question 1 they fall into the following categories: Proposal loser AND served on IGP Panel; Collaborator on a proposal; Collaborator on a proposal AND not a NOAA employee; Proposal loser AND collaborator on a proposal; no response. Question 2 produced three negative responses, including one that identified the benefits of the IGP as "none" and another that felt the program favors those who have already published a good deal. Negative responses to Question 3 included the following: IGP proposals require too much effort for too little payoff; the distribution of awards is too political and should be based on merit; and the program should be discontinued because it emphasizes "aesthetic science" rather than essential and mandated core NMFS missions and goals. Two negative responses were received to Question 4. One respondent, who had applied more than once without receiving an award, felt the program was "a waste of my time." The other offered this comment: "I realize this is a popular program (giving away money for someone to do what they want is always popular) but I've always been puzzled by the internal grants program. It doesn't seem to be focused on particular research priorities or needs, it takes money away from Divisions to support other research, and undermines a team or program manager to keep staff focused on research that is fully funded or high priority. Given the budget situation, I'm surprised there is any discussion of expanding or continuing it."

Challenges

A number of challenges arose in trying to implement the IGP, an early one being how to reconcile the diverse program goals (see above). Some newer employees felt the program was designed primarily for them, given its emphasis on career development and enhancing the grant-writing skills of junior scientists. On the other hand, the focus on providing seed money for novel, cutting-edge scientific research tended to favor more experienced scientists, some of whom won more than one award in the early years of the program. This issue was largely resolved in 2005 by creating separate tracks for Open and Junior Scientist competitions and by doubling the available funds to $400K. Although the higher level of funding proved not to be sustainable (Fig. 1), the two-track system provided a means for separately evaluating proposals from more- and less-experienced applicants. The two tracks did not have fixed allocations in terms of number or amount of awards; instead, proposals in the two tracks were evaluated separately using the same criteria, and then merged to produce an overall, prioritized list of projects recommended for funding. In no case did the Review Panel recommend funding for a proposal that was not considered outstanding scientifically, even if it was from a Junior Track applicant. However, in general a Junior Track proposal would receive a higher priority than an Open Track proposal with similar scores. Put another way, an Open Track proposal had a higher bar to meet to be competitive.

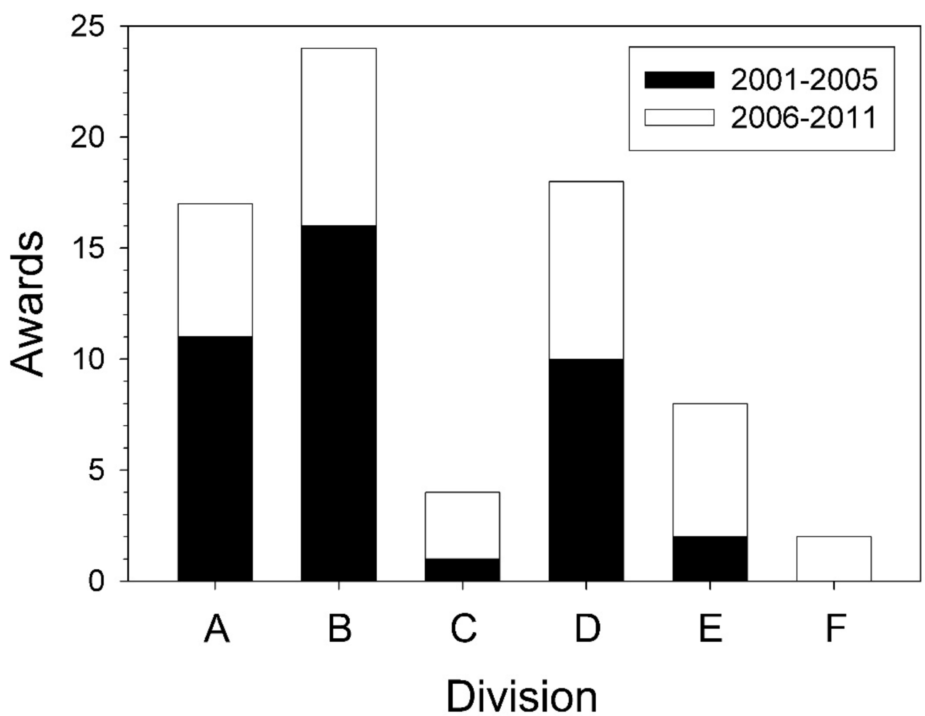

Figure 6. Distribution of awards by the Division of the lead Principal Investigator. Research by Divisions A, B, and D has a strong laboratory component, whereas Divisions C and E conduct extensive field work. Division F includes primarily administrative staff.

Although promoting cutting-edge research across each of the Center's research divisions was a goal of the program, awards for the first 5 years were concentrated primarily in three divisions (Fig. 6). These divisions are dominated by programs that rely heavily on external competitive funding for their research and staff had considerable experience with grant writing. Many of these staff are laboratory scientists, with strong ties to academic institutions and are experienced at writing competitive grants; not surprisingly, these divisions also submitted most of the grant applications. In contrast, one division primarily includes administrative staff, and two others focus heavily on field work, contract work, or routine stock assessments that provide less time and fewer opportunities for conducting original research. Efforts to more fully engage scientists in these other divisions and encourage participation in the IGP were moderately successful in the second 5 years of the program (Fig. 6).

Rigorous peer review is a central feature of the IGP, and each proposal received reviews from three internal (IGP Review Panel) members as well as at least one external reviewer, in addition to a summary of the Panel discussions/conclusions. Not surprisingly, not everyone was satisfied with outcomes of the process. Panel members were chosen to reflect the diversity of research areas within the Center, but the small number that were active in any given year (6-11) meant that panelists regularly had to evaluate proposals that were well outside their area of expertise. We did not necessarily consider this a serious flaw, as applicants were told that proposals should be free enough from jargon and other esoterica that they could be understood by scientists from other disciplines. In these circumstances, reviewers focused on evaluating the clarity of the presentation, whether the core problem or question had been clearly articulated, whether the general approach made sense in terms of the stated objectives, and whether contingency plans were made for unanticipated developments. Nevertheless, some applicants felt that reviewers of their proposals were not sufficiently qualified to provide a meaningful evaluation. External reviewers were selected for their subject matter expertise, but most had little or no prior experience with our system for proposal review; as a consequence their numerical scores were highly variable and sometimes difficult to integrate with the other scores from Panelists.

As articulated elsewhere, by far the biggest challenge faced by the IGP was uncertainty about the amount and timing of funds available for awards.

Relationship to Existing Programs

The National Marine Fisheries Service administers about a dozen programs that typically issue competitive requests for proposals each year, with total award amounts of approximately $10M. These national programs, which address important core, mission-related needs within the agency, differ from the NWFSC IGP in several important ways. First, many of these programs are targeted at very specific themes (e.g., ocean acoustics, sea turtle assessments, monitoring marine recreational fisheries) and hence narrowly define the range of proposals they will consider. The IGP is much more open-ended and encourages novelty and originality, provided the proposed research is broadly relevant to the agency's mission. Second, most of the national programs fund large projects; for example, the Advanced Sampling Technologies, Marine Recreational Information, Sea Turtle Assessments, Stock Assessment Methods Improvement, Fisheries and the Environment (FATE), and Cooperative Research programs all have average awards of about $100K - $200K per project. Awards in some of the national programs tend to go to more senior researchers, some of whom receive funds year after year. IGP awards tend to be much smaller, seed-money projects that last a maximum of 1 or 2 years (Fig. 2; 10-year mean project budget = $32K, median = $29K), and this provides ample opportunities for junior researchers to produce competitive proposals. Finally, although most of the national programs are administered through the NMFS Office of Science and Technology, they vary widely in how clear the selection criteria are, how transparent the evaluation process is, and how much feedback is given to applicants. In contrast, the IGP is administered entirely within a single Science Center, and many staff members have played key roles in developing and refining goals of the program. All applicants get four written peer reviews, as well as a summary of comments on their proposal by the Review Panel. This level of local involvement and transparency ensures that a substantial fraction of the staff feels vested in, and is committed to the success of, the program.

A Modest Proposal

Although creating and implementing the IGP at the NWFSC presented a number of challenges, the program has been so successful on so many levels that it deserves to be emulated elsewhere. For a little over $1M per year, something like the IGP could be replicated at each of the NMFS Science Centers. This would represent about one-tenth of 1% of the overall NMFS budget, and it is difficult to imagine how the money could be spent in a way that would produce a greater overall return on investment. Ideally, this agency-wide program would be funded by NMFS but implemented separately in each Science Center, which should provide more flexibility to tailor the program to particular needs or opportunities. The details provided here about operation of the NWFSC's IGP are offered not as a prescription for how things should be done, but rather as an example of what (after some trial and error) was found to work at the NWFSC during this time period.

It is important to stress that replication of something like the IGP across all the NMFS Science Centers should be seen as an addition to, and not a substitution for, the national competitive programs described in the previous section. The national programs address crucial agency mandates, but locally-administered programs like the IGP can do more to foster morale, innovation, and career development of junior scientists. All of these will be important to NMFS as it faces many daunting challenges in the coming decades, including attrition due to retirements and potential loss of institutional memory and expertise.

Acknowledgments

The NWFSC's Internal Grants Program enjoyed strong support by the Center throughout its tenure. Administrative assistance was cheerfully provided by Celina Hedger, Vicky Krikelas, and Diane Tierney. Vera Trainer headed up the mentoring program, Mary Moser and Penny Swanson led workshops on grant-writing skills, and Julie Peddy provided advice on preparing budgets. This program would not have been possible without the dedication and hard work of the following members of the Internal Grants Review Panel: Mary Arkoosh, Brian Beckman, Ed Casillas, Walt Dickhoff, Rick Gustafson, Owen Hamel, Jeff Hard, Eli Holmes, John Incardona, Chris Jordan, Peter Kareiva, Peter Kiffney, Peggy Krahn, Don Larsen, Phil Levin, Martin Liermann, Rick Methot, Sarah Morley, Mary Moser, Linda Park, Michael Pollock, Linda Rhodes, Beth Sanderson, Mark Strom, Penny Swanson, David Teel, Nick Tolimieri, Vera Trainer, Robin Waples, Laurie Weitkamp, John Williams, Gary Winans, Gina Ylitalo, Rich Zabel. Similarly, the IGP relied heavily on the goodwill and input from a wide range of peer reviewers from outside the Center. Walt Dickhoff, Ron Johnson, Sarah Morley, Bill Peterson, Penny Swanson, Usha Varanasi, and Eric Ward provided useful comments on an early draft of this report, or on specific sections. James Lee provided editorial assistance.

Appendices

Appendix A. List of winners of Internal Grants Program awards 27

Appendix B. List of spin-off grants based on research funded by the Internal Grants Program 33

Appendix C. List of peer-reviewed publications based on research funded by the Internal Grants Program 37

Appendix D. List of scientific presentations related to research funded by the Internal Grants Program 47

Appendix E. List of miscellaneous products of research funded by the Internal Grants Program 65

Appendix F. Summary of management applications of research funded by the Internal Grants Program 69

Appendix G. Internal Grants Program proposal guidelines and reviewer score sheets 75

Appendix A

Winners of NWFSC Internal Grants Program Awards

2001

Tim Beechie, *Recovery planning and sediment budget modeling in Puget Sound*

Andy Dittman, *Development and validation of a molecular assay for olfactory imprinting in Pacific salmon*

Rick Gustafson and Eric Iwamoto, *Development of species-specific molecular markers to identify and enumerate parasitic glochidia in wild salmonid juveniles*

Steven Kalinowski, *Diversification among sockeye salmon 'ecotypes' in Lake Washington: evidence for early stages of speciation*

Phil Levin and Mary Ruckelshaus, *Towards a life cycle model for Puget Sound Chinook salmon*

Linda Rhodes and Mark Strom, *Application of molecular tools to differentiate strains of Renibacterium salmoninarium to study transmission of bacterial kidney disease in salmon*

Nat Scholz, *Rapid phenotypic screening in zebrafish*

Penny Swanson, *Nature versus nurture: Do hatchery practices impair brain development and compromise fitness of salmon?*

2002

Andy Dittman, *Spatial scales of homing and the efficacy of hatchery acclimation facilities*

Blake Feist, *Towards an understanding of the influence of non-indigenous smooth cordgrass (*Spartina alterniflora*) on food web dynamics in Pacific Northwest estuaries*

Peter Kiffney, *Tributary junctions: hotspots of biological diversity and productivity?*

Donald Larsen, *Development of endocrine tools for determination of sexual maturation in male salmonids*

Jim Myers, *Life history and genetic analysis of archived salmon scales*

Linda Park, *Comparative genome mapping in Pacific Salmon: linking physical and genetic maps between rainbow trout and Chinook salmon*

George Pess, *Ecological and ecosystem consequences of dam removal for anadromous salmonids in the Elwha River*

Linda Rhodes, *Comparison of species-specific monocytic response to the causative agent of bacterial kidney disease,* Renibacterium salmoninarum

2003

Brian Beckman, *Validation of plasma IGF-I level as an index of instantaneous growth rate in salmon*

Sarah Morley, *Evaluating habitat restoration opportunities for Pacific salmon within the Duwamish River, an urban estuary*

Mary Moser, *Green sturgeon use of Washington estuaries*

Mark Myers and Mary Moser, *Use of acoustic tagging and telemetry to estimate the resident home range and habitat use by adult English sole in Puget Sound*

Jen Zamon, *Fish dynamics in the Columbia River and the estuarine turbidity maximum: Evaluating acoustics as a sampling tool*

2004

Correigh Greene, *Density dependence during estuarine residence in juvenile Chinook salmon*

Lyndal Johnson, *Indicators of endocrine disruption in English sole*

Rohinee Paranjpye, *The role for type IV pili of* Vibrio parahaemolyticus *in environmental persistence*

Karen Peck-Miller, *Development of biochemical and molecular biomarkers of exposure to estrogenic contaminants in Pacific salmon*

Penny Swanson, *Improving homing fidelity in Pacific salmon: Neuroendocrine enhancement of olfactory function*

Gary Winans, *Dynamics of steelhead recolonization of the Green River: I Population genetics and phenetics*

2005

<u>Junior Track</u>

Pip Courbois, *Methods for interactive and dynamic visualization of monitoring data*

Aimee Fullerton, *Testing tools for science-based recovery planning: Sensitivity analysis of a Decision Support System and application to restoration of watersheds containing ESA-listed Pacific salmonids*

Tom Good, *Estimating avian predation impacts on juvenile salmonids in the mid-Columbia River*

John Incardona, *Identification of physiologically relevant biomarkers of PAH exposure for fish early life history stages using the zebrafish DNA microarray*

Eric Iwamoto, *Examining early 20th century scales of sockeye salmon on the Columbia River to assess the current genetic status of extant ESUs*

David Kuligowski, *Stuck in a rut: Is hybridization with coastal cutthroat trout a barrier to steelhead recovery?*

Kathi Lefebvre, *The effects of domoic acid (DA) on salmon behavior, physiology, and DA tissue concentrations with implications for domoic acid exposure to resident killer whales during harmful algal blooms in the Pacific Northwest*

Piper Schwenke, *Forensic voucher specimen collection and molecular genetic analysis for species identification of commercially important groundfish*

Ashley Steel, *Landscape structure versus content: Impacts of large-scale land use on salmon and their habitats*

Open Track

Andrew Dittman, *Development of a bioassay for natural odor detection and discrimination in salmonids*

Eli Holmes, *Development of risk assessment software and training for analysis of population count data*

Michael Pollock and Tim Beechie, *Evaluating the restoration potential of incised streams in semi-arid regions of the Columbia River basin*

Linda Rhodes, *Identification of molecular markers of cell-mediated immunity in Chinook salmon*

Beth Sanderson, *Importance of marine-derived nutrients in stream food webs: implications for juvenile Chinook*

2006

Junior Track

Keith Bosley, *Using stable isotopes and feeding habits to examine the feeding ecology of young-of-the-year rockfish (genus* Sebastes*) off Oregon and Washingt*on

Brian Burke, *Coho salmon behavior in the Elwha River: Implications for recolonization after dam removal*

Lawrence Hufnagle, *Application of newly calibrated SM20 90kHz multibeam sonar system to survey rockfish,* Sebastes *spp*

Sarah Morley, *Effects of salmon carcasses on riverine foodwebs: An experimental field study on the Elwha River*

Karma Norman, *Assessing institutional designs for managing water supply to support salmon recovery in Puget Sound*

Frank Sommers, *Interaction between avoidance of dissolved copper and the attraction of structural habitat in juvenile Chinook salmon (*Oncorhynchus tshawytscha*)*

Open Track

Mary Moser, *Mixing of green sturgeon (*Acipenser medirostris*) population segments during summer aggregation in Washington estuaries*

Rich Zabel, *Using otolith microchemistry to distinguish natal origin and habitat use of spring/summer Chinook salmon in the Snake River basin*

2007

Junior Track

Nicholas Adams, *Use of microsatellite markers and toxicity testing to identify* Pseudo-nitzschia australis *populations posing the greatest threat to Puget Sound fisheries*

Ewann Berntson, *Deep-sea coral DNA repository for the NE Pacific*

Ronald Johnson, *Examining the transport of lipids to oocyte yolk in coho slamon* (Oncorhynchus kisutch) *during secondary oocyte growth*

Kathi Lefebvre, *Long-term effects of domoic acid in the vertebrate central nervous system*

Dawn Noren, *The dynamics of persistent organic pollutant (POP) transfer from female cetaceans to their offspring during gestation and lactation*

Open Track

Kelly Andrews, *A new approach to assessing biological response to marine protected areas: plasma insulin-like growth factor -I (IGF-I) levels in Puget Sound lingcod*

Deborah McArthur and Phil Levin, *Econauts in the Estuary: A role for high school students in marine conservation*

2008

None

2009

Junior Track

Aimee Fullerton, *Using measures of freshwater habitat connectivity for conservation planning*

Daniel Lomax, *Characterization of chemical contaminant concentrations in adult and sub-adult bluntnose sixgill sharks* (*Hexanchus griseus*) *from Elliot Bay and other sites within Puget Sound*

Open Track

Brian Beckman, *Developing a comprehensive measure of fish growth*

Tom Good, *Seabird-fish prey links and ecosystem health indicators*

Ashley Steel, *From experiments to landscapes: Physiological, behavioral, and ecological consequences of altered thermal regimes during Chinook salmon incubation*

2010

Junior Track

Paul Chittaro, *Suitability of somatic growth of English sole as an ecosystem indicator*

Katy Doctor, *Local adaptation in Hood Canal Steelhead? Genetic variability for reaction norms for early life history traits between two populations*

Jeff Jorgensen, *Validating classification models that use morphometrics to identify ancient salmonid* (Oncorhynchus spp) *vertebrae to species*

Jonathan Lee, *Recapture of aquaculture escapes via acoustic recall*

Adam Luckenbach, *Next generation sequencing and assembly of sablefish gonadal transcriptomes during early sexual development*

Open Track

Chris Harvey and Kelly Andrews, *Movement patterns of Puget Sound jellyfish: are abiotic factors related to jellyfish distribution?*

Linda Rhodes and Anne Baxter, *Bacterial community profiling at sewage treatment plant outfalls*

2011

Junior Track

Kinsey Frick, *Effects of heightened levels of suspended solids on the spawning movements of adult winter steelhead in the Elwha River*

Cathy Laetz, *The combined toxicity of pesticide mixtures and elevated temperature to juvenile coho salmon*

Jose Reyes-Tomassini, *Feeding response of sablefish larva at different stages of development to purified livefeed extracts*

Open Track

Bill Fairgrieve, *Stable isotope analysis as a tool to determine the metabolic fates of dietary carbohydrates from plant-based alternative feed ingredients for the carnivorous sablefish,* Anaplopoma fimbria

Mary Moser, *Developing a non-invasive method to assess green sturgeon condition*

Beth Sanderson and Matthew Nesbit, *Nonnative predators in Columbia River reservoirs: Working with recreational anglers to examine predatory impacts on ESA-listed salmonids*

Appendix B

Spin-off Grants

The following grants were secured at least in part based on results of research projects funded by the NWFSC Internal Grants Program. Format: PIs for spinoff grant, all from NWFSC unless otherwise specified (**names of initial IGP winner(s) and year of award in bold**); Title of spin-off grant, funding source, and dates covered by new funding; Total amount awarded (rounded to nearest $1,000).

Grantee	Project	Award
Andrew Dittman (2001)	Assessment of captive broodstock technologies: determining critical imprinting periods for sockeye salmon. Bonneville Power Administration Environment, Fish and Wildlife, 2002-2009	$1,240,000
Andrew Dittman (2001), Bill Muir, and Doug Marsh	Evaluation of methods to reduce straying rates of barged juvenile steelhead	$500,000
Kathi Lefebvre, Vera Trainer, and **Nat Scholz (2001)**	Effects of algal toxin exposure in early life history stages of fish. The muli-agency Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) Program, 2002-2005	$277,000
Nat Scholz (2001) and John Incardona	Evaluating the effects of forestry herbicides on early life history stages of fish. U.S. Forest Service, Pesticide Impact Assessment Program. 2003-2004	$105,000
John Incardona and **Nat Scholz (2001)**	Mechanisms of petroleum hydrocarbon toxicity in fish at early life history stages. Oiled Wildlife Care Network, 2003-2005	$147,000
Nat Scholz (2001) and John Incardona	The toxicity of the insecticide fipronil to developing zebrafish. NOAA (NOS) Coastal Storms Program, 2004	$100,000
Linda Rhodes (2001), Donald Larsen, **Andy Dittman (2003)**, Tim Hoffnagle (ODFW), and Sonia Mumford (USFWS)	Estimating the impact of bacterial kidney disease on spring Chinook salmon adult returns. NOAA Fisheries FCRPS Biological Opinion Implementation (BiOp), 2007-2008	$153,000
Donald Larsen (2002)	Growth modulation in salmon supplementation. Bonneville Power Administration, 2002-2015	$4,127,000
Donald Larsen (2002)	Hood River spring Chinook salmon and steelhead physiology. Bonneville Power Administration Environment, 2008-2014	$1,086,000

Donald Larsen (2002)	Physiology of summer Chinook salmon reared in a partial water reuse system. Chelan County Public Utility District, 2009-2011	$391,000
Donald Larsen (2002)	Biologically-based size targets for upper Columbia River summer Chinook salmon. Chelan County Public Utility District, 2013-2015	$375,000
Donald Larsen (2002)	Technical consultation for physiology of upper Columbia River spring and summer Chinook salmon. Grant County Public Utility District, 2013-2015	$300,000
Donald Larsen (2002)	Assessing early male maturation in spring Chinook salmon supplementation programs of the mid-Columbia River. NOAA Fisheries FCRPS Biological Opinion Implementation (BiOp), 2006-2008	$150,000
Brian Beckman (2002)	Columbia River Basin Juvenile Salmonids: Survival and Growth in the Columbia River Plume and northern California Current (growth measures). Bonneville Power Administration, 2004-2014	$800,000
Brian Beckman (2002)	Marine IGF1 levels of yearling Columbia River Chinook Salmon. NOAA Fisheries FCRPS Biological Opinion Implementation (BiOp), 2006-2014	$900,000
Brian Beckman (2002) and Joe Orsi (AKFSC)	Salmon growth as an indicator of ecosystem variability. Fisheries and the Environment Program (FATE, NOAA), 2009–2010	$211,000
Brian Beckman (2002) and Marc Trudel (DFO, Canada)	Assessing growth of juvenile salmon in the Strait of Georgia. Pacific Salmon Commission, 2012-2014	$175,000
George Pess (2002)	Predicting freshwater ecosystem response to the removal of the Elwha River dams. NOAA restoration center, 2003-2004	$140,000
Peter Kiffney (2002) and Correigh Greene	Tributary junctions: hotspots of biological productivity and diversity? Earthwatch Institute, 2003-2006	$75,000
Sarah Morley (2003)	Fish use of modified shoreline habitats in the Duwamish River Estuary. Environmental Conservation Division, NWFSC, 2004	$5,000
Andrew Dittman (2003), Mary Moser, Don Larsen, George Pess, and Christian Torgersen (UW)	Spatial scales of homing and the efficacy of hatchery acclimation facilities. NOAA Fisheries FCRPS Biological Opinion Implementation (BiOp), 2007-2011	$800,000
Andrew Dittman (2003) and Christian Torgersen (UW)	Imprinting hatchery-reared salmon to targeted spawning locations by manipulating odor exposure during critical developmental periods. Grant County Public Utility District, 2012	$25,000

Jeannette Zamon (2003)	Fishery-independent sampling of adult eulachon from the lower Columbia River during the 2012-2013 spawning run. NOAA Protected Resources Division, Portland, OR, 2012-2013	$65,000
John Horne and **Jeannette Zamon (2003)**	The influence of plumes on predator-prey interactions. Bonneville Power Administration, 2011-2014	$149,000
Correigh Greene (2004) and Eric Beamer	Monitoring of population responses by Skagit River Chinook salmon to estuary restoration. Washington Department of Ecology, Intensively Monitored Watersheds Project, 2005-2015	$2,200,000
Michael Pollock (2005), Tim Beechie, and Chris Jordan	A process-based approach to identifying and restoring incised stream ecosystems that are important to salmonids. NOAA Fisheries FCRPS Biological Opinion Implementation (BiOp), 2006-2014	$900,000
Chris Jordan, **Michael Pollock (2005),** Nick Bouwes and Nick Weber (Ecological Research, Inc.), and Carol Volk (South Fork Research)	A long-term experimental approach to restoring incised streams using beaver and beaver dam analogues to benefit the mid-Columbia River steelhead ESU. Bonneville Power Administration, 2007-2014	$2,400,000
Piper Schwenke (2005)	NWFSC Forensic Marine Fish Voucher Collection. NOAA Office of Law Enforcement (OLE), 2005-2013	$138,000
Eli Holmes (2005) and Eric Ward	NMFS Protected Species Assessment Tool Development and Applications: Deploying protected species tools via cloud computing. NOAA Fisheries Office of Protected Species, 2013 and ongoing	$100,000
Sarah Morley (2006)	Seasonal variation in aquatic foodweb response to salmon carcass addition in the Elwha River. Lower Elwha Klallam Tribe, 2008	$40,000
Sarah Morley (2006)	Understanding the direct and indirect effects of dam removal on water quality and primary and secondary productivity in the Elwha River. USGS-NPS Water Quality Partnership Program, 2014-2016	$150,000
Mary Moser (2006) and Steve Lindley (SWFSC)	Feeding and habitat use of green sturgeon *(Acipenser medirostri*s) in Washington estuaries. NMFS Species of Concern Program, 2008-2009	$35,000
Mary Moser (2006) and Steve Lindley (SWFSC)	Coastal movement patterns and habitat use of sub-adult green sturgeon *(Acipenser medirostri*s). NMFS Office of Protected Resources Program, 2009-2011	$109,000

Ewann Berntson (2007)	Taxonomic and genetic identification of fisheries bycatch of deep-sea corals. NOAA Deep-Sea Coral Research and Technology Program, 2009-2013	$290,000
Ron Johnson (2007), William Fairgrieve, Penny Swanson, Brian Beckman	Sustainable aquafeeds for marine finfish: Effects of vegetable oil replacement feeds containing novel microalgal and fungal oils on growth performance of juvenile sablefish *Anoplopoma fimbria*. NOAA Aquaculture Program, 2008-2009	$209,000
Kathi Lefebvre (2007)	Long-term effects of chronic algal toxin exposure in the vertebrate central nervous system. The multi-agency Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) Program, 2008-2012	$346,000
Kathi Lefebvre (2007) and Dave Marcinek (UW)	A novel antibody-based biomarker for toxicity of chronic domoic acid exposure. Multi-agency RO1 from the National Institute of Environmental Health Sciences (NIEHS) and National Science Foundation (NSF), 2012-2017	$1,337,000
Kathi Lefebvre (2007), Dave Marcinek (UW) and Bridget Ferriss	A model for realistic human consumption levels of domoic acid in the Pacific Northwest. National Institutes of Health (NIH) Supplement Award 2014-2016	$242,000
Correigh Greene, Casimir Rice, **Linda Rhodes (2010),** and Kurt Fresh	Evaluating the ecological health of Puget Sound's pelagic foodweb. EPA Region 10, 2010-2012	$700,000

Appendix C

Peer-reviewed Publications Resulting From Internal Grants Program Awards

2001 Winners

Bacon, C.R., P. K. Weber, K, A, Larsen, R. Reisenbichler, J. A. Fitzpatrick, and J. L. Wooden. 2004. Migration and rearing histories of Chinook salmon (*Oncorhynchus tshawytscha*) determined by ion microprobe Sr isotope and Sr/Ca transects of otoliths. Can. J. Fish. Aquat. Sci. 61:2425-2439.

Bartz, K. K., K. M. Lagueux, M. D. Scheuerell, T. J. Beechie, A. D. Haas, and M. H. Ruckelshaus. 2006. Translating restoration scenarios into habitat conditions: an initial step in evaluating recovery strategies for Chinook salmon (*Oncorhynchus tshawytscha*). Can. J. Fish. Aquat. Sci. 63:1578-1595.

Beechie, T.J., G. Pess, E. Beamer, G. Lucchetti, and R.E. Bilby. 2003. Role of watershed assessments in recovery planning for endangered salmon. *In* D. Montgomery, S. Bolton, D. Booth, and L. Wall (eds), Restoration of Puget Sound rivers, p. 194-225. University of Washington Press, Seattle.

Beechie, T., G. Pess, S. Morley, L. Butler, P. Downs, A. Maltby, P. Skidmore, S. Clayton, C. Muhlfeld, and K. Hanson. 2013. Chapter 3: Watershed assessments and identification of restoration needs. *In* P. Roni and T. Beechie (eds.), Stream and watershed restoration: A guide to restoring riverine processes and habitats, p. 50-113. Wiley-Blackwell, Chichester, UK.

Brynildsrud, O, E.J. Feil, J. Bohlin, S. Castillo-Ramirez, D. Colquhoun, U. McCarthy, I.M. Matejusov, L.D. Rhodes, G.D. Wiens, and D.W. Verner-Jeffreys. 2014. Microevolution of *Renibacterium salmoninarum*: evidence for intercontinental dissemination associated with fish movements. *The ISME Journal* 8:746-756.

Carls, M.G., Holland, L., Larsen, M., Collier, T.K., Scholz, N.L., and Incardona, J.P. 2008. Fish embryos are damaged by dissolved PAHs, not oil particles. Aquat. Toxic. 88:121-127.

Carvan, M.J.,J. P. Incardona, and M. L. Rise. 2008. Meeting the challenges of aquatic vertebrate toxicology. BioScience 58:1015-1025.

Coady, A.M., A. L. Murray, D. G. Elliott, and L. D. Rhodes. 2006. Both *msa* genes in *Renibacterium salmoninarum* are needed for full virulence in bacterial kidney disease. Appl. Environ. Micro. 72:2672-2678.

Colman, J.R., D. H. Baldwin, L. L. Johnson, and N. L. Scholz. 2009. Effects of the synthetic estrogen, 17a-ethinylestradiol, on aggression and courtship behavior in male zebrafish. Aquat. Toxic. 91:346-354.

Greene, C. M., and T. J. Beechie. 2004. Consequences of potential density-dependent mechanisms on recovery of ocean-type chinook salmon (*Oncorhynchus tshawytscha*). Can. J. Fish. Aquat. Sci. 61:590-602.

Greene, C. M., D. Jensen, G. R. Pess, E. M. Beamer, and E. A. Steel. 2005. Effects of environmental conditions during stream, estuary, and ocean residency on Chinook salmon return rates in the Skagit River, WA. Trans. Am. Fish. Soc. 134:1562-1581.

Gustafson, R. G., and E. Iwamoto. 2006. A DNA-based identification key to Pacific Northwest freshwater mussel glochidia: importance to salmonid and mussel conservation. North. Sci. 79:233–245.

Hatlen, K., C. A. Sloan,D. G. Burrows, T. K. Collier, N. L. Scholz, and J. P. Incardona. 2010. Natural sunlight and residual fuel oils are a lethal combination for fish embryos. Aquat. Toxic. 99:56-64.

Hicken, C. E., T. L. Linbo, D. W. Baldwin, M. S. Myers, M. L. Willis, L. Holland, M. Larsen, M. S. Stekoll, S. D. Rice, T. K. Collier, N. L. Scholz, and J. P. Incardona. 2011. Sublethal exposure to crude oil during embryonic development alters cardiac morphology and reduces aerobic capacity in adult fish. Proc. Nat. Acad. Sci. 108:7086-7090.

Incardona, J., M. G. Carls, H. Teraoka, C. A. Sloan, T. K. Collier, N. L. Scholz. 2005. Aryl hydrocarbon receptor-independent toxicity of weathered crude oil during fish development. Envir. Health Perspect. 113:1755-1762.

Incardona, J. P., T. K. Collier, and N. L. Scholz. 2004. Defects in cardiac function precede morphological abnormalities in fish embryos exposed to polycyclic aromatic hydrocarbons. Toxic. Appl. Pharm. 196:191-205.

Incardona, J. P., T. K. Collier, and N. L. Scholz. 2010. Oil spills and fish health: exposing the heart of the matter. J. Expos. Sci. Envir. Epidem. 21:3-4.

Incardona, J., H. L. Day, T. K. Collier, N. L. Scholz. 2006. Developmental toxicity of 4-ring polycyclic aromatic hydrocarbons in zebrafish is differentially dependent on AH receptor isoforms and hepatic cytochrome P4501A metabolism. Toxic. Appl. Pharm., 217:308-321.

Incardona, J. P., T. L. Linbo, and N. L. Scholz. 2011. Cardiac toxicity of 5-ring polycyclic aromatic hydrocarbons is differentially dependent on the aryl hydrocarbon receptor 2 isoform during zebrafish development. Toxic. Appl. Pharm 257:242-249.

Kendall, N. W., A. H. Dittman, and T.P. Quinn. 2010. Comparative maturation schedules of two Columbia River sockeye salmon *Oncorhynchus nerka* populations. Endang. Spec. Res. 13:51-61.

Kihslinger, R.L., S.C. Lema, & G.A. Nevitt. 2006. Environmental rearing conditions produce differences in the relative brain size of wild Chinook salmon *Oncorhynchus tshawytscha*. Comp. Biochem. Physiol. (A) 145:145-151.

Lefebvre, K.A., V. L. Trainer, and N. L. Scholz. 2004. Morphological abnormalities and sensorimotor deficits in larval fish exposed to dissolved saxitoxin. Aquat. Toxic. 66:159-170.

Lema, S. C., I. R. Schultz, N. L. Scholz, J. Incardona, and P. Swanson. 2007. Neural defects and cardiac arrhythmia in fish larvae following embryonic exposure to 2,2',4,4'-tetrabromodiphenyl ether (PBDE 47). Aquat. Toxic. 82:296-307.

Linbo, T.L., D. H. Baldwin, J. K. McIntyre, and N. L. Scholz. 2009. Effects of water hardness, alkalinity, and dissolved organic carbon on the toxicity of copper to the lateral line of developing fish. Envir. Toxic. Chem. 28:1455-1461.

Linbo, T.L., C. M. Stehr, J. P. Incardona, and N. L. Scholz. 2006. Dissolved copper triggers cell death in the peripheral mechanosensory system of larval fish. Envir. Toxic. Chem. 25:597-603.

Rhodes, L. D., A.M. Coady, and R.K. Deinhard. 2004. Identification of a third *msa* gene in *Renibacterium salmoninarum* and the Associated Virulence Phenotype. Appl. Environ. Microbiol. 70:6488-6494.

Roni, P. and T. Beechie. 2013. Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats. Wiley-Blackwell, Chichester, UK.

Stehr, C.M., T. L. Linbo, J. P. Incardona, and N. L. Scholz. 2006. The insecticide fipronil causes notochord degeneration and locomotor defects in zebrafish during early development. Toxic. Sci. 92:270-278.

Stehr, C.M., T. L. Linbo, N. L. Scholz, and J. P. Incardona. 2009. Evaluating effects of forestry herbicides on fish development using zebrafish rapid phenotypic screens. N. Am. J. Fish. Manage. 29:975-984.

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Beckman, B.R. and D.A. Larsen. 2005. Up-stream migration of PIT-tagged Age 2 (minijack) Chinook salmon in the Columbia River: Behavior, abundance, distribution, and origin. Trans. Am. Fish. Soc. 134:1520-1541.

Brenkman, S. J., G. R. Pess, C. E. Torgersen, K. K. Kloehn, J. J. Duda, and S. C. Corbett. 2008. Predicting recolonization patterns and interactions between potamodromous and anadromous salmonids in response to dam removal in the Elwha River, Washington State, USA. North. Sci. 82 (Special Issue):91-106.

Bond, M., B. R. Beckman, L. Rohrbach, and T. Quinn. 2014. Differential growth in estuarine and freshwater habitats indicated by plasma IGF1 concentrations and otolith chemistry in Dolly Varden *Salvelinus malma.* J. Fish. Biol. 85:1429-1445.

Daly, E.A., J. A. Scheurer, R. D. Brodeur, L. A. Weitkamp, B. R. Beckman, and J.A. Miller. 2014. Juvenile steelhead distribution, migration, feeding, and growth in the Columbia River estuary, plume, and coastal waters. Mar. Coast. Fisheries 6:62-80.

Eldridge, W.H., J.M. Myers, and K.A. Naish. 2009. Long-term changes in the fine-scale population structure of coho salmon populations (*Oncorhynchus kisutch*) subject to extensive supportive breeding. Heredity 10: 299-309.

Ferriss, B.E., M. Trudel, and B.R. Beckman. 2014. Assessing marine pelagic ecosystems: Regional and inter-annual trends in marine growth rates of juvenile salmon off the British Columbia coast. Mar. Ecol. Prog. Ser. 503:247-261.

Harstad, D.L., D.A. Larsen, and B.R. Beckman. 2014. Variation in minijack rate among Columbia River Basin hatchery Chinook salmon populations. Trans. Am. Fish. Soc. 143:768-778.

Iwamoto, E.M., J.M. Myers, and R.G. Gustafson. 2012. Resurrecting an extinct salmon evolutionarily significant unit: Archived scales, historical DNA and implications for restoration. Mol. Ecol. 21: 1567-1582.

Kiffney, P. M., C. Greene, J. Hall, and J. Davies. 2006. Gradients in habitat heterogeneity, productivity and diversity at tributary junctions. Can. J. Fish. Aquat. Sci. 63: 2518-2530.

Kloehn, K.K., T.J. Beechie, S.A. Morley, H.J. Coe, and J.J. Duda. 2008. Influence of dams on river-floodplain dynamics in the Elwha River, Washington. North. Sci. 82 (Special Issue):224-235.

Larsen, D.A., B. R. Beckman, and K. A. Cooper. 2010. Examining the conflict between smolting and precocious male maturation in spring (stream-type) Chinook salmon. Trans. Am. Fish. Soc. 139:564-578.

Larsen, D.A., Beckman, B.R., Cooper, K.A., Barrett, D., Johnston, M., Swanson, P., and Dickhoff, W.W. 2004. Assessment of high rates of precocious male maturation in a spring Chinook salmon supplementation hatchery program. Trans. Am. Fish. Soc. 133:98-120.

Larsen, D. A., B. R. Beckman, C. R. Strom, P. Parkins, K. A. Cooper, D. E. Fast, and W. W. Dickhoff. 2006. Growth modulation alters the incidence of early male maturation and physiological development of hatchery reared spring Chinook salmon: a comparison with wild fish. Trans. Am. Fish. Soc., 135:1017-1032.

Larsen, D.A., D. L. Harstad, C. R. Strom, M. V. Johnston, C. M. Knudsen, D. E. Fast, T. N. Pearsons, and B. R. Beckman. 2013. Early life history variation in hatchery- and natural-origin spring Chinook salmon in the Yakima River, Washington. Trans. Am. Fish. Soc. 142:540-555.

Larsen, D. A., M. Shimizu, K. A. Cooper, P. Swanson, and W. W. Dickhoff. 2004. Androgen effects on plasma GH, IGF-I, and 41-kDa IGFBP in coho salmon (*Oncorhynchus kisutch*). Gen. Comp. Endocrin. 139:29-37.

McHenry, M.L. and G.R. Pess. 2008. An overview of monitoring option for assessing the response of salmonids and their aquatic ecosystems in the Elwha River following dam removal. North. Sci. 82 (Special Issue):29-47.

Pess, G. R., M. L. McHenry, T. J. Beechie, and J. Davies. 2008. Biological impacts of the Elwha River dams and potential salmonid responses to dam removal. North. Sci. 82 (Special Issue):72-90.

Phillips, R. B., M. R. Morasch, L. K. Park, K. A. Naish, and R. H. Devlin. 2005. Identification of the sex chromosome pair in coho salmon (*Oncorhynchus kisutch*): lack of conservation of the sex linkage group with chinook salmon (*Oncorhynchus tschwytscha*). Cyto. Genome Res. 111:166-70.

Rice, S., P. Kiffney, C. Greene, and G. Pess. 2008. Influences of tributary junctions on biological gradients and confluence 'hotspots'. *In* S. Rice, A. G. Roy, and B. Rhoades (eds.) River confluences, tributaries and fluvial networks, p. 209-237. Wiley Publishing, New York.

Roni, P., M. McHenry, G. R. Pess, and T. J. Beechie. 2008. Evaluating changes in salmon spawning habitat and spawners in the Elwha River following dam removal. Am. Fish. Soc. Symp. 65:301-320.

Ruesink, J. L., B. E. Feist, C. J. Harvey, J. S. Hong, A. C. Trimble and L. M. Wisehart. 2006. Changes in productivity associated with four introduced species: Ecosystem transformation of a "pristine" estuary. Mar. Ecol. Prog.Ser. 311:203-215.

Shimizu, M., K. A. Cooper, W. W. Dickhoff, and B. R. Beckman. 2009. Postprandial changes in plasma growth hormone, insulin, insulin-like growth factor (IGF)-I and IGF-binding proteins in coho salmon (*Oncorhynchus kisutch*) fasted for varying periods. Am. J. Physiol.--Integ. Comp. Physiol. 297:352-361.

Spangenberg, D., D.A. Larsen, R. Gerstenberger, C. Brun, and B.R. Beckman. 2014. The effects of variation in rearing conditions on growth, smolt development, and minijack rate in yearling Chinook salmon: a hatchery-scale experiment. Trans. Am. Fish. Soc. 143:1220-1230.

2003 winners

Adams, P. B., C. B. Grimes, J. E. Hightower, S. T. Lindley, and M. L. Moser. 2007. Population status of North American green sturgeon, *Acipenser medirostris.* Environ. Biol. Fish. 79:339-356.

Beckman, B. R., M. Shimizu, B. A. Gadberry, P. Parkins, and K. A. Cooper. 2004. The effect of temperature change on the relations among plasma IGF-1, 41-kDa IGFBP, and growth rate in postsmolt coho salmon. Aquaculture. 241:601-619.

Cram, J., C. E. Torgersen, R. Klett, G. R. Pess, D. May, T. N. Pearsons, and A.H. Dittman. 2012. Tradeoffs between homing and habitat quality for spawning site selection by hatchery-origin Chinook salmon. Environ. Biol Fish. 96:109-122.

Dittman, A.H., D. May, D. A. Larsen, M. Moser, M. Johnston, and D. Fast. 2010. Homing and spawning site selection of supplemented hatchery and natural origin Yakima River spring Chinook salmon (*Oncorhynchus tshawytscha*). Trans. Am. Fish. Soc. 139:1014-1028.

Metzger, D.C., J.A. Luckenbach, J.T. Dickey, B.R. Beckman. 2013. Development of a multiplex gene expression assay for components of the endocrine growth axis in coho salmon. Gen. Comp. Endocrinol. 189:134-140.

Metzger, D.C., J.A. Luckenbach, M. Shimizu, and B.R. Beckman. 2012. Normalizing for biology: accounting for technical and biological variation in levels of reference gene and insulin-like growth factor 1 (*igf1*) transcripts in fish livers. Comp. Biochem. Physiol. A 163:7-14.

Morley, S.A., J.D. Toft, and K.M. Hanson. 2012. Ecological effects of shoreline armoring on intertidal habitats of a Puget Sound urban estuary. Estuar. Coasts 35:774-784.

Moser, M. L., and S. T. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environ. Biol. Fish. 79:243-253.

Moser, M. L., M. S. Myers, J. E. West, S. M. O'Neill, and B. J. Burke. 2013. English sole spawning migration and evidence for feeding site fidelity in Puget Sound, U.S.A. with implications for contaminant exposure. North. Sci. 87:317-325.

Moser, M.L., M.S. Myers, B.J. Burke, and S.M. O'Neill. 2005. Effects of surgically-implanted transmitters on survival and feeding behavior of adult English sole. *In:* M.T. Spedicato, G. Marmulla, and G. Lembo (eds) Aquatic Telemetry: Advances and Applications, pp. 1-7. FAO-COISPA, Rome.

2004 winners

Frischkorn, K.R., A.B. Stojonovski, and R.N. Paranjpye. 2013. *Vibrio parahaemolyticus* type IV pili mediate interactions with diatom-derived chitin and point to an unexplored mechanism of environmental persistence. Environ. Microbiol. 15:1416–1427.

Paranjpye, R. N. M.S. Myers, E. Yount and J. Thompson. 2013. Zebrafish as a model host for *Vibrio parahaemolyticus* virulence. Microbiology 159:2605-2615.

Winans, G. A., M. C. Baird, and J. Baker. 2010. A genetic and phenetic baseline before the recolonization of steelhead above Howard Hanson Dam, Green River, Washington. N. Am. J. Fish. Manage. 30:742-756.

2005 Winners

Beechie, T. J., G. R. Pess, M. M. Pollock, M. H. Ruckelshaus, and P. Roni. 2009. Restoring Rivers in the 21st Century: Science Challenges in a Management Context. *In* Beamish, R. J. and Rothschild, B. J. (eds.), p. 697-717. The future of fisheries science in North America. Springer Science, New York.

Beechie, T.J., M.M. Pollock, and S. Baker. 2008. Channel incision, evolution and potential recovery in the Walla Walla and Tucannon River basins, northwestern USA. Earth Surf. Proc. Land. 33:784-800.

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Chittaro, P. M., R. W. Zabel, K. Haught, B. L. Sanderson, and B. P. Kennedy. 2014. Spatial and temporal patterns of growth and consumption by juvenile spring/summer Chinook salmon *Oncorhynchus tshawytscha*. Environ. Biol. Fish. 97:1397-1409.

Elliott, D.G., G.D. Wiens, K.L. Hammell, L.D. Rhodes. 2014. *Vaccination against bacterial kidney disease*. *In*: Fish Vaccination. R Gudding, A Lillehaug and Ø Evensen, **p.** 255-272. Chichester, UK, John Wiley & Sons, Ltd.

Ellner, S. P. and E. E. Holmes. 2008. Resolving the debate on when extinction risk is predictable. Ecol. Let. 11:E1–E5.

Feist, B.E., E.A. Steel, D.W. Jensen and D.N.D Sather. 2010. Does the scale of our observational window affect our conclusions about correlations between endangered salmon populations and their habitat? Land. Ecol. 25:727–743.

Fullerton, A.H., D. Jensen, A. Steel, D. Miller, and P. McElhany. 2010. How certain are salmon recovery forecasts? A watershed-scale sensitivity analysis. Environ. Model. Assess. 15:13-26.

Fullerton, A.H., A. Steel, Y. Caras, and I. Lange. 2010. Effects of spatial pattern and economic uncertainties on freshwater habitat restoration planning: a simulation exercise. Rest. Ecol. 18(S2):354-369.

Fullerton, A.H., A. Steel, Y. Caras, M. Sheer, P. Olson, and J. Kaje. 2009. Putting watershed restoration in context: Alternative future scenarios influence management outcomes. Ecol. Applic. 19:218-235.

Holmes, E. E., J. L. Sabo, S. V. Viscido, and W. Fagan. 2007. A statistical approach to quasi-extinction forecasting. Ecol. Let. 10:1182–1198

Holmes, E. E. and E. J. Ward. 2010. Analysis of multivariate time series using the MARSS package. User Guide for the MARSS package. http://cran.r-project.org/web/packages/MARSS/vignettes/UserGuide.pdf

Holmes, E. E., E. J. Ward and K. Wills, 2012. MARSS: Multivariate autoregressive state-space models for analyzing time-series data. The R Journal Vol. 4/1:11-19.

Iwamoto, E. M., J. M. Myers, and R. G. Gustafson. 2012. Resurrecting an extinct salmon evolutionarily significant unit: archived scales, historical DNA, and implications for restoration. Mol. Ecol. 21:1567–1582.

Lefebvre, K.A., D.P. Noren, I.R. Schultz, S.M. Bogard, J. Wilson, and B-T.L. Eberhart. 2007. Uptake, tissue distribution and excretion of domoic acid after oral exposure in coho salmon (*Oncorhynchus kisutch*). Aquat. Toxic. 81:266-274.

Maranto, C. J., T. P. Good, F. K. Weise, and J. K. Parrish. 2010. Impact of the Potholes Reservoir Caspian Tern breeding colony on out-migrating juvenile salmonids in the Mid-Columbia River. Trans. Am. Fish. Soc. 139:362-381.

Pollock, M. M., Beechie, T. J., and Jordan, C. E. 2007. Gemorphic changes upstream of beaver dams in Bridge Creek, an incised stream in the interior Columbia River basin. Earth Surf. Process. Land. 32:1174-1185.

Rhodes, L. D., S. Wallis, and S. E. Demlow. 2009. Genes associated with an effective host response by Chinook salmon to *Renibacterium salmoninarum*. Devel. Comp. Immun. 33:176-186.

Safford, T., and K. Norman. 2011. Planning Salmon recovery: applying sociological concepts to spawn new organizational insights. Soc. Nat. Res. 24:751-766.

Safford, T., and K. Norman. 2011. Water water everywhere, but not enough for a salmon to swim? Organizing integrated water and fisheries management in Puget Sound. J. Environ. Manage. 92:838-847.

Viscido, S. V. and E. E. Holmes. 2010. LAMBDA: A software tool for statistical modeling of communities and ecosystems. Environ. Model. Soft. 25:1905-1908

2006 Winners

Bosley, K.L., T.W. Miller, R.D. Brodeur, K.M. Bosley, A. Van Gaest, and A. Elz. 2014. Feeding ecology of juvenile rockfishes off Oregon and Washington based on stomach content and stable isotope analyses. Mar. Biol. 161:2381-2393.

Burke, B. J., K. E. Frick, R. E. Moses, and M. L. McHenry. 2008. Movements by coho salmon in the Lower Elwha River, Washington. North. Sci. 82:119-127.

Lindley, S.T., M.L . Moser, D. L. Erickson, M. Belchick, D. W. Welch, E. Rechisky, J. T. Kelly, J. Heublein, and A. P. Klimley. 2008. Marine migration of North American green sturgeon. Trans. Am. Fish. Soc. 137:182-194.

Lindley, S T., D. L. Erickson, M. L. Moser, G. Williams, O. P. Langness, B. McCovey, Jr., D. Vogel, W. Pinnix, J. T. Kelly, J. C. Heublein, and A. P. Klimley. 2011. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. Trans. Am. Fish. Soc. 140:108-122.

Williams G. D., K. S. Andrews, S. L. Katz, M. L. Moser, N. Tolimieri, D. A. Farrer, and P. S. Levin. 2012. Scale and pattern of broadnose sevengill shark *Notorynchus cepedianus* movement in estuarine embayments. J. Fish Biol. 80:1380-1400.

Zabel, R.W., K. Haught, and P. Chittaro. 2010. Variability in fish size/otolith size relationships among populations of Chinook salmon. Environ. Biol. Fish. 89: 267-278.

2007 Winners

Andrews, K.S., B.R. Beckman, A.H. Beaudreau, D.A. Larsen, G.D. Williams, and P.S. Levin. 2011. Suitability of insulin-like growth factor 1 (IGF1) as a measure of relative growth rates in lingcod. Mar. Coastal Fish. 3:250-260.

Beaudreau, A.H., K.S. Andrews, G. Young, D.A. Larsen, and B.R. Beckman. 2011. Variation in plasma levels of insulin-like growth factor-I (IGF-I) in lingcod: relationships among season, size, and gonadal steroids. Mar. Biol. 158:439-450.

Cairns, Stephen D., Robert P. Stone, Ewann A. Berntson, and Shirley A. Pomponi. 2015. Species Discovery of Deep-Water Corals and Sponges in US Waters (2007-2012). *In:* The State of Deep-Sea Coral and Sponge Ecosystems of the United States: 2015 -- Thomas F. Hourigan, Peter J. Etnoyer, Stephen D. Cairns, Eds.

Hiolski, E., P. Kendrick, E. Frame, R. Beyer, T. Bammler, F. Farin, J. Wilkerson, M. Myers, D. Smith, D. Marcinek, and K.A. Lefebvre. 2014. Chronic low level domoic acid exposure alters gene transcription and impairs mitochondrial function in the CNS. Aquat. Toxic. 155:151-159.

Johnson, R.B., E.L. Kroeger, C.S. Carter, W.L. Reichert, and M.B. Rust. 2011. Transitioning coho salmon *Oncorhynchus kisutch* broodstock to a docosahexaenoic acid (DHA)-rich diet during vitellogenesis: Effects on egg composition, and embryo and fry quality. North Am. J. Aqua. 73:409-417.

Johnson R.B., E. L. Kroeger, W.L. Reichert, D.M. Deavila, and M.B. Rust. 2013. Abundance and origins of plasma lipids in sexually maturing female coho salmon *Oncorhynchus kisutch* (Walbaum) in culture. Aqua. Res. 45:1771-1781.

Lefebvre, K.A., S.C. Tilton, T.K. Bammler, R.P. Beyer, S. Srinouanprachan, P.L. Stapleton, F.M. Farin, and E.P. Gallagher. 2009. Gene expression profiles in zebrafish brain after acute exposure to domoic acid at symptomatic and asymptomatic doses. Tox. Sci. 107(1):65-77.

Lefebvre, K.A., E.R. Frame, F. Gulland, J.D. Hansen, P.S. Kendrick, R.P. Beyer, T.K. Bammler, F.M. Farin, E.M. Hiolski, D.R. Smith, and D.J. Marcinek. 2012. A novel antibody-based biomarker for chronic algal toxin exposure and sub-acute neurotoxicity. PLoS ONE 7:5:1-7.

2009 winners

Fullerton, A.H., K.M. Burnett, E.A. Steel, R.L. Flitcroft, G.R. Pess, B.E. Feist, C.E. Torgerson, D.J. Miller, and B.L. Sanderson. 2010. Hydrological connectivity for riverine fishes: measurement challenges and research opportunities. Fresh. Biol. 55:2215-2237.

Fullerton, A.H., S.T. Lindley, G.R. Pess, B.E. Feist, E.A. Steel, and P. McElhany. 2011. Human influence on the spatial structure of threatened Pacific salmon metapopulations. Conserv. Biol. 25:932-944.

Steel, E.A., A. Tillotson, D.A. Larsen, A.H. Fullerton, K.P. Denton, and B.R. Beckman. 2012. Beyond the mean: The role of variability in predicting ecological impacts of stream temperature. Ecospheres 3(11):1-11.

2010 winners

Doctor, K.K., B. Berejikian, J.J. Hard, and D. Van Doornik. 2014. Growth-mediated life history traits of steelhead reveal phenotypic divergence and plastic response to temperature. Trans. Am. Fish. Soc. 143:317-333.

Guzman, J.M., J.A. Luckenbach, and P. Swanson. 2013. Molecular characterization and quantification of sablefish (*Anoplopoma fimbria*) gonadotropins and their receptors: reproductive dysfunction in female captive broodstock. Gen. Comp. Endocrinol. 193:37-47.

Israel. J. A., M. Neuman, M. L. Moser, S. T. Lindley, B. W. McCovey Jr., D. Erickson, and A. P. Klimley. In Press. Recent advances in understanding the life history of green sturgeon (*Acipenser medirostris*) and potential anthropogenic threats to this imperiled fish. American Fisheries Society Special Publication.

Moriarty, P. E., K. S. Andrews, C. J. Harvey, and M. Kawase. 2012. Vertical and horizontal movement patterns of scyphozoan jellyfish in a fjord-like estuary. Mar. Ecol. Prog. Ser. 455:1-12.

Smith, E.K., J.M. Guzman, and J.A. Luckenbach. 2013. Molecular cloning, characterization and sexually dimorphic expression of five major sex differentiation-related genes in a Scorpaeniform fish, sablefish (*Anoplopoma fimbria*). Comp. Biochem. Physiol. Part B 165:125-137.

2011 winners

Laetz, C.L., D.H. Baldwin, V.R. Heber, J.D. Stark, and N.L. Scholz. 2014. Elevated temperatures increase the toxicity of pesticide mixtures to juvenile coho salmon. Aquat. Toxic. 146:38-44.

Appendix D

Scientific Presentations Related to Research Funded by the NWFSC Internal Grants Program

Principal investigator(s) of the original grant are shown in **bold** [or **bold in brackets** if not authors of the presentation].

2001 Grants

Beechie, T., G. Pess, and G. Luchetti. Roles of watershed assessment in restoration planning. Society for Ecological Restoration. Bellevue, WA, 2001.

Beechie, T., M. Pollock, B. Feist, G. Pess, and P. Roni. Deserts to rainforests: erosion regimes and the recovery of Pacific Salmon. Geological Society of America Annual Meeting. Seattle, WA, 2003.

Dittman, A.H., D. May, D. Baldwin, N. Scholz, and J. Athos. Life stage and odorant-induced changes in olfactory sensitivity in Coho salmon (*Oncorhynchus kisutch*). Seventh International Congress on the Biology of Fish. St John's, Canada, July 2006 (invited).

Dittman, A.H., D. May, D. Baldwin, N. Scholz, and J. Athos. Developmental changes in olfactory sensitivity in Coho salmon (*Oncorhynchus kisutch).* Chemical Signals in Vertebrates IX. Chester, England, July 2006 (invited).

Dittman, A.H., D. May, D. Baldwin, N. Scholz. Plasticity in olfactory sensitivity in Coho salmon, *Oncorhynchus kisutch*. Association for Chemoreception Science 26th Annual Meeting. Sarasota, Florida, 2004.

Dittman, A.H., and D. May. Life stage and odorant-induced changes in olfactory sensitivity in Coho salmon, *Oncorhynchus kisutch.* Chemical Signals in Vertebrates X. Corvallis, Oregon, 2003.

Dittman, A.H., D. May, and M. Havey. Odorant induced changes in olfactory receptor mRNA expression during imprinting in Pacific salmon. Society for Integrative and Comparative Biology annual meeting. Seattle, WA, January 2010.

Dittman, A.H., D. May, and M. Havey. Developmental and odor-induced and changes in odorant receptor mRNA expression during olfactory imprinting and homing in Pacific salmon, *Oncorhynchus* spp. Association for Chemoreception Science annual meeting. St. Petersburg, FL, April 2010.

Dittman, A.H. Mechanism of olfactory imprinting and homing in pacific salmon International Congress on the Biology of Fishes. Barcelona, Spain, July 2010 (Invited).

Larsen, K., E. Volk, and E. Beamer. Comparing otolith chemistry and microstructure as life history indicators of habitat use by Chinook salmon. American Fisheries Society. Anchorage, AK, 2005 **[Levin, 2001]**.

Rhodes, L.D., A.M. Coady, and M.S. Strom. Molecular genetics of major soluble antigen (MSA) in the salmonid pathogen, *Renibacterium salmoninarum.* 4th International Symposium on Aquatic Animal Health. New Orleans, LA, September 2002.

Rhodes, L.D., A.M. Coady, and S.C. Corbett. Occurrence of more than two *msa* genes in *Renibacterium salmoninarum* and the associated virulence phenotype. Western Fish Disease Conference. Seattle, WA, July 2003.

Coady, A.M., and **L.D. Rhodes**. Disruption of the msa1 gene in the salmon pathogen *Renibacterium salmoninarum*. 6th Annual UW Undergraduate Research Symposium. Seattle, WA, May 2003 (poster).

Rhodes, L.D., R.K. Deinhard, and A.M. Coady. Genotyping and genetic manipulation of *Renibacterium salmoninarum.* Symposium on Bacterial Kidney Disease - Challenge for the 21st Century. Seattle, WA, November 2005.

Rhodes, L.D., A.E. Baxter, S. Gee, T. Hoffnagle, C.A. Rice, O. Brynildsrud, and D. Verner-Jeffreys. Bacterial kidney disease in salmonids - new aspects to an old disease. US-Russia Workshop on Aquaculture & Fish Health. Seattle, WA, October 2012.

Work using the zebrafish system (**Scholz, 2001**) has been presented by several NWFSC personnel (Scholz, Incardona, Lefebvre, Stehr, and Linbo), as both platform presentations and posters at a wide range of scientific meetings, including:

- Pacific Coast Herring Workshop and Herring Summit (2002)
- Georgia Basin-Puget Sound Research Conference (2003, 2005)
- Society for Environmental Toxicology and Chemistry (2003, 2004, 2005)
- Society for Developmental Biology Northwest Regional Conference (2003, 2004, 2005, 2006)
- Pollutant Responses in Marine Organisms International Symposium (2003, 2005)
- Marine Science in Alaska Symposium (2005)
- Cape Flattery Oil Spill Risk Assessment Workshop (2005)
- Estuarine Research Foundation Conference (2005)
- NOAA Oceans and Human Health Initiative All PI's Annual Meeting (2006)

2002 Grants

Beckman, B., D. Spangenberg, and **D.A Larsen.** Environmental effects on smolt quality and early male maturation in spring Chinook salmon. Northwest Fish Culture Conference. Portland, OR, December 2010.

Beckman, B., D. Spangenberg, **D.A Larsen**, and D. Harstad. Emergence timing and life history in Chinook salmon. 141st Annual Meeting, American Fisheries Society. Seattle, WA, September 2011.

Beckman, B.R., D. Teel, S. Nance, and L. Rohrbach. Early Male Maturation of Chinook Salmon Caught at Sea. 141st Annual Meeting, American Fisheries Society. Seattle, WA, September 2011 **[Larsen, 2002].**

Eldridge, W., K. Naish, and **J. Myers**. Decadal changes in genetic diversity of Puget Sound coho salmon. Puget Sound Georgia Basin Research Conference. Seattle, WA, 2005.

Feist, B.E., C.J. Harvey, J.L. Ruesink, and A.C. Trimble. The influence of non-indigenous smooth cordgrass, *Spartina alterniflora*, on estuarine ecosystems of the Pacific Northwest. International Association for Landscape Ecology annual meeting. Las Vegas, Nevada, 2004.

Feist, B., C. Harvey, J. Ruesink, A. Trimble, and N. Richardson. The influence of non-indigenous smooth cordgrass, *Spartina alterniflora* on food web dynamics in Pacific Northwest estuaries Part II: Spatio-temporal patterns of oyster growth and diet. Estuarine Research Federation annual meeting. Seattle, WA, September 2003.

Feist, B.E., C.J. Harvey, J.L. Ruesink, and A.C. Trimble. "Inconspicuous" impacts of *Spartina alterniflora* in a temperate eastern Pacific estuary. 5th Marine Bioinvasions Conference. Cambridge, MA, 2007.

Feist, B.E., C.J. Harvey, J.L. Ruesink, and A.C. Trimble. "Inconspicuous" impacts of non-indigenous species in a Pacific Northwest estuary. International Conference on Aquatic Invasive Species. Key Biscayne, FL, 2006.

Greene, C. and **P. M. Kiffney.** Tributary junctions: hotspots of biodiversity? Ecological Society Annual Meeting. Portland, OR, 2004.

Harvey, C., **B. Feist,** J. Ruesink, A. Trimble, and L. McCoy. The influence of non-indigenous smooth cordgrass, *Spartina alterniflora* on food web dynamics in Pacific Northwest estuaries, Part I: System scale influence on oyster diets. Estuarine Research Federation annual meeting. Seattle, WA, September 2003.

Iwamoto, E. The Grand Coulee Fish Maintenance Project: a genetic blender or evidence for local adaptation in Columbia River sockeye salmon. American Fisheries Society Annual Meeting. Seattle, WA, September 2011.

Kiffney, P., C. Greene, and T. Good. Role of tributary junctions in creating gradients of physical, chemical and biological attributes in mainstem rivers. Skagit River Research Symposium. La Conner, WA, 2005.

Kiffney, P., C. Greene, and T. Good. Role of tributary junctions in creating gradients of physical, chemical and biological attributes in mainstem rivers. American Society of Limnology and Oceanography Annual Meeting. Salt Lake City, UT, 2005.

Kiffney, P. M. and C. Greene. Network connections: implications for biodiversity. North American Benthological Society Annual Meeting. Vancouver, BC, 2004 (Invited).

Kiffney, P. M. and C. Greene**.** Network connections: implications for conservation of Pacific salmon. World Fisheries Conference. Vancouver, BC, 2004 (Invited).

Kiffney, P. M. and C. Greene. Network connections: implications for conservation of Pacific salmon. North Cascade National Park's Science Days. Mt. Vernon, WA, 2004.

Kiffney, P. M, C. Greene and T. Good. Reach-scale patterns of riverine productivity and diversity: influence of tributary junctions. 40th Annual Meeting, American Geophysical Union. San Francisco, CA, December 2007 (Invited).

Kiffney, P. M. River networks and habitat connections: influence of tributary junctions. 26th Annual Meeting, US-IALE Landscape Ecology Meeting. Portland, OR, April 2011 (Invited).

Kiffney, P. M. Biological ramifications of spatial discontinuities created by tributary junctions. 141st Annual Meeting, American Fisheries Society. Seattle, WA, September 2011 (Invited).

Kiffney, P. M. and G. Pess. The dynamics and ecological effects of salmon recolonization: Lessons learned from the Cedar River, WA. 141st Annual Meeting, American Fisheries Society. Seattle, WA, September 2011 (Invited).

Larsen, D.A., B.R. Beckman, D. Harstad, C. Knudsen, S. Schroder, and D. Fast. Warning! That big smolt may be a tiny adult: prevalence, causes and consequences of Chinook salmon minijacks. 141st Annual Meeting, American Fisheries Society. Seattle, WA, September 2011.

Larsen, D.A., B.R. Beckman, D. Harstad, C. Knudsen, S. Schroder, and D. Fast. Warning! That big smolt may be a tiny adult: prevalence, causes and consequences of Chinook salmon minijacks. 141st Annual Meeting, American Fisheries Society. Seattle, WA, September 2011.

Larsen, D.A., B.R. Beckman, D. Harstad, P. Parkins, K.A. Cooper, D. Spangenberg, L, Rohrbach, S. Nance, and A. Tillotson. Early male maturation and domestication selection in hatchery spring Chinook salmon. 141st Annual Meeting, American Fisheries Society. Seattle, WA, September 2011.

Larsen, D.A. Co-chaired a session and give an oral presentation on factors affecting age-at-maturity and life history diversity in salmon. Workshop on Age and Size at Maturity of Pacific Salmon and Steelhead. Portland, OR, May 2011.

Larsen, D.A., B.R. Beckman, D. Harstad, D. Spangenberg, L. Felli, S. Nance, and A. Tillotson. Warning! That big smolt may be a tiny adult: prevalence, causes and consequences of Chinook salmon minijacks. Northwest Fish Culture Conference. Portland, OR, December 2010.

Larsen, D.A., D.L. Harstad, and B.R. Beckman. Minijack prevalence in spring Chinook salmon of the Yakima River, Washington: Management implications for determining smolt-to-adult return rates. Annual meeting of the American Fisheries Society. Pittsburgh, PA, September 2010 (poster).

Larsen, D.A., D.L. Harstad, and B.R. Beckman. Minijack prevalence in wild and hatchery spring Chinook salmon of the Yakima River, Washington. State of the Salmon Conference examining Ecological interactions between wild and hatchery salmon. Portland, OR, May 2010 (poster).

Larsen, D.A. Precocious male maturation in spring Chinook salmon at the WDFW Seminar series. Olympia, WA, December 2009 (invited).

Larsen, D.A., B.R. Beckman, D. Harstad, P. Parkins, K.A. Cooper, and D. Spangenberg. Warning! That BIG smolt may be a tiny adult: The tale of the "migrating minijack". 8th International Smoltification Workshop. Bend, OR, September 2009.

Larsen, D.A., B.R. Beckman, P. Parkins, D. Harstad, K.A. Cooper, D. Spangenberg, D.E. Fast, C. Strom, and M. Johnston. Evaluation of yearly and geographic variation in early male maturation in hatchery and wild spring Chinook salmon from the Yakima River, Washington. Yakima Basin Aquatic Science and Management Conference. Ellensburg, WA, June 2009.

Larsen, D.A., B.R. Beckman, P. Parkins, D. Harstad, K.A. Cooper, D. Spangenberg, D.E. Fast, C. Strom, and M. Johnston. Precocious male maturation in Cle Elum spring Chinook salmon: Update. Yakima Basin Aquatic Science and Management Conference. Ellensburg, WA, June 2008.

Larsen, D.A., B.R. Beckman, C. Strom, P. Parkins, K.A. Cooper, M. Johnston, D. Fast, and W.W. Dickhoff. High rates of age-2 precocious male maturation, "Minijacks", in spring Chinook salmon hatchery programs: prevalence, causes, and potential solutions. 58th Annual Northwest Fish Culture Conference. Portland, OR, December 2007.

Larsen, D.A., B.R. Beckman, and W.W. Dickhoff. Growth modulation and precocious male maturation in Yakima River spring Chinook salmon: an update. Yakima Basin Aquatic Science and Management Conference. Ellensburg, WA, June 2007.

Larsen, D.A., B.R. Beckman, P. Parkins, K.A. Cooper, and W.W. Dickhoff. Physiology and precocious male maturation of hatchery spring Chinook salmon. Yakima Basin Aquatic Science and Management Conference. Ellensburgh, WA, June 2006.

Larsen, D.A., B.R. Beckman, K.A. Cooper, and W.W. Dickhoff. Are smolting and male maturation mutually exclusive? A physiological comparison between precociously maturing male and smolting spring Chinook salmon. 7th International Smoltification Workshop. Tono, Japan, July 2005.

Larsen, D.A., B.R. Beckman, P. Parkins, and K.A. Cooper. Early detections of precocious male maturation in salmonids. 135th Annual Meeting, American Fisheries Society. Anchorage, AK, September 2005.

Larsen, D.A., B.R. Beckman, P. Parkins, K.A. Cooper, and W.W. Dickhoff. Physiology and precocious male maturation of hatchery spring Chinook salmon. Yakima Basin Aquatic Science and Management Conference. Ellensburg, WA, June 2005.

Larsen, D.A., B.R. Beckman, P. Parkins, K.A. Cooper, P. Swanson, and W.W. Dickhoff. Physiology and precocious male maturation of wild and hatchery Yakima Spring Chinook salmon. Yakima Basin Aquatic Science and Management Conference. Ellensburgh, WA, June 2004.

Larsen, D.A., B.R. Beckman, P. Parkins, K.A. Cooper, and W.W. Dickhoff. Physiology and precocious male maturation of hatchery spring Chinook salmon. Yakima Basin Aquatic Science and Management Conference. June, 2005, Ellensburg, WA.

Larsen, D.A., B.R. Beckman, P. Parkins, K.A. Cooper, P. Swanson, and W.W. Dickhoff. Physiology and precocious male maturation of wild and hatchery Yakima Spring Chinook salmon. Yakima Basin Aquatic Science and Management Conference. June, 2004, Ellensburg, WA.

Larsen, D.A., B.R. Beckman, and W.W. Dickhoff. Precocious male maturation in the Yakima River – the anti-smolt. Smolt Workshop. Hood River, OR, February 2004.

Larsen, D.A., B.R. Beckman, P. Parkins, K.A. Cooper, and W.W. Dickhoff. Effects of growth on precocious male maturation of salmon. Northwest Fish Culture Conference. Portland, OR, December 2003.

Larsen, D. A., B.R. Beckman, and W.W. Dickhoff. Effects of growth on precocious male maturation of salmon. USFWS Hatchery Management Workshop. Pasco, WA, March 2003.

Larsen, D. A., B.R. Beckman, K.A. Cooper, P. Parkins, N.G. Hodges, J.T. Dickey, B. Gadberry, and W.W. Dickhoff. Physiology and precocious male maturation of hatchery spring Chinook salmon. Yakima Basin Aquatic Science and Management Conference. Ellensburgh, WA, March 2003.

Neely, K.G, R.K. Gustafson, **E.M. Iwamoto**, and **J.M. Myers**. A tale from scales: Can we learn anything from reading fish scales about the effects of climate change? American Fisheries Society Annual Meeting. Seattle, WA, September 2011.

Paquin, M., **J. Myers**, and P. Moran. Reduced genetic structure among steelhead hatchery stocks relative to wild populations in the Snake River Basin: An exploration of historical biogeography. Coastwide Salmonid Genetics Meeting, 2004.

Phillips, R.P., M.R. Morasch, **L.K. Park,** R.H. Devlin, and G.H. Thorgaard. Sex chromosomes, sex linkage groups in Pacific salmon and trout: possible transposition of the male-specific region. Society for Study of Reproduction. August 2004, Vancouver, BC.

Pess, G. Predicting ecosystem response to the removal of the Elwha River Dams. American Geophysical Union. San Francisco, CA, Dec 2005 (invited).

Pess, G. P redicting salmon response to the removal of the Elwha River Dams. Puget Sound – Georgia Basin Research Conference. Seattle, WA, March 2005 (invited).

Pess, G. Elwha River dam removal presentation. Society of Ecological Restoration. Seattle, WA, April 2005 (invited).

Pess, G. Elwha River research consortium. Society of Ecological Restoration. Seattle, WA, April 2005.

2003 Grants

Beckman, B.R., J. Fisher, C.A. Morgan, and S. Hinton. Summer growth of post-smolt coho salmon off the Oregon/Washington Coast, as assessed by plasma insulin-like growth factor I level, varies inter-annually and is related to subsequent adult survival. PICES/NPAFC Joint Symposia. Jeju Island, Republic of Korea, November 2005.

Beckman, B.R. Smolts at sea: assessing growth and performance of post-smolt coho salmon off the Oregon-Washington Coast. 7th International Workshop on Salmonid Smoltification. Tono, Japan, July 2005.

Beckman, B.R. Validation of plasma insulin-like growth factor-I as a growth index with application to relative growth rates of oceanic post-smolt coho salmon. AFS 135th Annual Meeting. Anchorage, AK, September 2005.

Beckman, B.R., M. Shimizu, B. Gadberry, P. Parkins, and K. Cooper. Temperature and the relations among plasma IGF-I, 41 kDa IGFBP, and growth in coho salmon. Society of Integrative and Comparative Biology. New Orleans, LA, January 2004.

Beckman, B.R., and M. Shimizu. Response of plasma IGF-I level to feeding in post-smolt coho salmon. Fifth International Symposium on Fish Endocrinology. University Jaume I of Castellon, Castellon, Spain, September 2004, (Poster).

Luckenbach J.A., D.C. Metzger, J.T. Dickey, P. Swanson, and **B.R. Beckman**. Development and validation of a quantitative multiplex gene expression assay for components of the endocrine growth axis in salmon. Society for Integrative and Comparative Biology meeting. Seattle, WA, January 2010.

Beckman B.R., J.A. Luckenbach, D.C. Metzger, M. Shimizu, and J.T. Dickey. Endocrine control of growth in coho salmon: validation of a multiplex gene expression assay and quantification of relations between messenger RNA levels and proteins during feeding and fasting. Society for Integrative and Comparative Biology meeting. Seattle, WA, January 2010.

Dittman, A.H. 2010. Spatial and temporal interactions between hatchery and wild spring Chinook salmon spawning and effects of hatchery acclimation sites. State of the Salmon Conference: Ecological Interactions between Wild & Hatchery Salmon. Portland, OR, May 2010 (invited).

Dittman, A.H. Homing patterns and spawning site selection of Yakima River spring Chinook salmon. Yakima Basin Science and Management Conference. Ellensburg, WA, June 2010.

Morley, S.A., J.D. Toft, and K.M. Hanson. Nearshore habitat restoration in an ultra-urban estuary: what can we realistically hope to achieve? American Fisheries Society 135th Annual Meeting. Anchorage, AK, September 2005.

Morley, S.A., J.D. Toft, and K.M. Hanson. Evaluating habitat restoration opportunities for Pacific salmonids within the Duwamish River, an urban estuary. Tuesday morning seminar series, The Water Center, University of Washington. Seattle, WA, November 2004 (Invited).

Morley, S.A., J.D. Toft, and K.M. Hanson. Evaluating habitat restoration opportunities within the Duwamish River Estuary. Restore America's Estuaries National Conference on Coastal and Estuarine Habitat Restoration. Seattle, WA, September, 2004.

Morley, S.A., J.D. Toft, and K.M. Hanson. Evaluating habitat restoration opportunities for Pacific salmon within the Duwamish River, an urban estuary. Society for Conservation Biology 18th Annual Meeting. New York, NY, July 2004.

Morley, S.A., J.D. Toft, K.M. Hanson, A. Pratt, and T.R. Bennett. Evaluating habitat restoration opportunities for Pacific salmon within the Duwamish River. NWFSC Watershed Program 3rd Annual Open House. Seattle, WA, October 2003.

Moser, M.L. and S.T. Lindley. Green sturgeon use of Washington estuaries. California/Nevada Chapter, American Fisheries Society. Sacramento, CA, March 2005.

Lindley, S.T. and **M.L. Moser.** Acoustic tagging of green sturgeon. Advanced Sampling Technology Workshop. Seattle, WA, August 2005.

Moser, M. L. and S. T. Lindley. Green sturgeon use of Washington estuaries. Gilbert Ichthyological Society. Eatonville, WA, October 2005.

Lindley, S.T. and **M.L. Moser.** Acoustic tagging of green sturgeon. American Fisheries Society national Meeting. Anchorage, AK, September 2005.

Zamon, J.E. Seabirds, seals, and salmon: marine predators as fisheries oceanographers. Hatfield Marine Science Center Seminar Series. Newport, OR, March 2004 (invited).

Zamon, J.E. Marine predators as fisheries oceanographers. Oregon Institute of Marine Biology Summer Seminar Series. Charleston, OR, August 2004 (invited).

Zamon, J.E. Where the Columbia meets the sea: river plumes as unique seabird habitat on the Oregon and Washington coasts. AVES seminar, Oregon State University. Corvallis, OR, March 2008 (invited).

Zamon, J.E. Study of physical and biological processes causing variation in fish habitat use and performance. Fish Ecology Science Symposium. Astoria, OR, November 2008.

Zamon, J.E. and E.M. Phillips. Physical-biological coupling in the Columbia River estuary and plume. Oregon Graduate Institute, Oregon Health and Sciences University. Beaverton, OR, February 2009 (invited).

Zamon, J.E. Seabirds, seals, and salmon: marine predators as fisheries oceanographers. Columbia River Maritime Museum Public Enrichment Series. Astoria, OR, February 2010 (invited).

Zamon, J.E., E.M. Phillips, and L.H. Reinalda. Spatial and temporal structure of marine predator-prey interactions in the Columbia River Plume. Ocean Sciences Annual Meeting. Portland, OR, February 2010.

Zamon, J.E., E.M. Phillips, L.H. Reinalda, and T. J. Guy. Spatial and temporal structure of marine bird and fish interactions in the Columbia River Plume. 1st World Seabird Conference. Vancouver, BC, September 2010.

Zamon, J.E. Untitled presentation on use of acoustics to map eulachon distribution in the lower Columbia River. Point Adams Lunchtime Series Forage Fish Workshop. Hammond, OR, February 2012.

2004 Grants

Felli, L., J. Dickey, **K.A. Peck-Miller**, D.P. Lomax, L. Johnson and P. Swanson. Effect of estradiol-17β on gonadal steroidogenic acute regulatory protein (star) gene expression in English sole (*Pleuronectes vetulus*). Washington State University, Center of Reproductive Biology Annual Retreat. Pullman, WA, June 2005 (poster).

Frischkorn, K., **R. Paranjpye,** C. Durkin, and V. Armbrust. The role of type IV pili of *Vibrio parahaemolyticus* in adherence to plankton. OHH symposium and Workshop. Washington D.C., April 2010.

Frischkorn, K., **R. Paranjpye,** C. Durkin, and V. Armbrust. The role of type IV pili of *Vibrio parahaemolyticus* in adherence to plankton. Gordon Research Conference. Biddeford, ME, June 2010.

Greene, C.M. Life history diversity of Chinook salmon: results from an integrated monitoring program in the Skagit River. NWFSC Monster Jam Speaker Series. Seattle, WA, December 2004.

Greene, C.M., and E. Beamer. Estuary-nearshore connections and their importance for estuary restoration. NWFSC Watershed Program 4th Open House. Seattle, WA, October 2005.

Johnson, L.L., D. P. Lomax, M.S. Myers, P. Swanson, L. Felli, J.E. West, and S.M. O'Neill. Xenoestrogen exposure and altered reproductive timing in Puget Sound English sole. 26th annual meeting of Society of Environmental Toxicology and Chemistry. Baltimore, MD, November 2005.

Paranjpye, R., W. Nilsson, A. Johnson, and M. Strom. Characterization of type IV pili and persistence of *Vibrio parahaemolyticus.* Conference Proceedings Coastal Zone '07. Portland, OR, July 2007.

Paranjpye, R., A. Johnson, D. Capps, S. Moseley, and M. Strom. Characterization of type IV pili of *Vibrio parahaemolyticus*. Conference Proceedings Coastal Zone '07. Portland, OR, July 2007.

Winans G. Recolonization of *O. mykiss* above dams. Annual meeting of the American Fisheries Society. San Francisco, CA, September 2007.

2005 Grants

Beechie, T., M. Pollock and J. Baker. Channel incision and potential recovery in semi-arid river basins. 10th International Symposium on Regulated Streams. Stirling, Scotland, 2006.

Beechie, T., G. Pess, and G. Luchetti. Roles of watershed assessment in restoration planning. Society for Ecological Restoration. Bellevue, WA, 2006.

Chittaro, P. R. Zabel, K. Haught, and **B. Sanderson.** Ecological Insights from Chinook Otoliths. Lecture at UW Tacoma, 2008.

Chittaro, P. R. Zabel, K. Haught, and **B. Sanderson.** Hard Science: Ecological Insights from Chinook otoliths. Lunch seminar, NWFSC. Seattle, WA, 2008.

Chittaro, P. Fish ecology: From individuals to communities. University of Canterbury, New Zealand, 2008 [**Sanderson, 2005**].

Chittaro, P. R. Zabel, K. Haught, and **B. Sanderson**. A bioenergetics approach to understanding growth of juvenile Chinook salmon. Fish Ecology Symposium, 2008.

Demlow, S.E., S. Wallis, and **L.D. Rhodes**. Nucleotide polymorphisms in interferon-gamma from Chinook salmon, *Oncorhynchus tshawytscha*. 11th Annual UW Undergraduate Research Symposium. Seattle, WA, May 2008 (poster).

Elz, A. **P. Schwenke,** L. Park, J. Hyde, T. Pietch, and D. Matthews. NWFSC Marine voucher collection: DNA barcodes for species ID. Hatfield Marine Science Center Seminar. Newport, OR, April 2009.

Fullerton, A.H., A. Steel, Y. Caras, M. Sheer, P. Olson, and J. Kaje. Estimating habitat conditions and salmonid population responses in the Lewis River watershed. Western Division American Fisheries Society meeting. Portland, OR, May 2008.

Fullerton, A.H., A. Steel, Y. Caras, and I. Lange. Spatial and economic impacts on watershed-scale restoration planning. American Fisheries Society Annual Meeting. San Francisco, CA, September 2007; and Watershed Program Open House. Seattle, WA, November 2007.

Fullerton, A.H., A. Steel, Y. Caras, M. Sheer, P. Olson, and J. Kaje. When the salmon return: watershed management strategies for above-dam habitat restoration. Oregon Chapter American Fisheries Society meeting. Eugene, OR, February 2007.

Fullerton, A.H., A. Steel, P. McElhany, M. Sheer, P. Olson, Y. Caras, D. Miller, D. Jensen, M. Maher, and J. Burke. A watershed-scale decision support system for habitat recovery planning: evaluation of alternative management strategies in the Lewis River watershed (Washington, USA). North American Benthological Society Annual Meeting. Anchorage, AK, June 2006.

Fullerton, A., A. Steel, P. McElhany, M. Sheer, P. Olson, Y. Caras, D. Miller, D. Jensen, M. Maher, and J. Burke. Evaluating freshwater habitat options for conservation of listed salmonids in the Lewis River watershed. Northwest Salmonid Recovery Conference. Seattle, WA, February 2006.

Good, T.P., and C.W. Thompson. Gone fishin': predation of Columbia River salmonids by Caspian terns commuting from off-river colonies. Pacific Seabird Group. Anchorage, AK, February 2006.

Good, T.P. Conservation of Pacific Salmon: challenges and strategies. Walla Walla College Marine Station. Anacortes, WA, June 2006.

Good, T.P. Having our fish and eating them too: conservation of Pacific salmon. Cornell University Shoals Marine Laboratory. Appledore Island, ME, June 2006.

Good. T.P. Avian predation by Potholes Reservoir-nesting Caspian terns. U.S. Army Corps of Engineers Mid-Columbia River Avian Predation Workshop. Richland, WA, July 2006.

Good, T.P. Avian predation by Potholes Reservoir-nesting Caspian terns. U.S. Army Corps of Engineers Avian Predation Subgroup Meeting for the Study Review Work Group - Anadromous Fish Evaluation Program. Walla Walla, WA, May 2006.

Good, T.P. Avian predation by Potholes Reservoir-nesting Caspian terns. Army Corps of Engineers Mid-Columbia River Avian Predation Workshop. Richland, WA, May 2007.

Good, T.P. Avian predation by Potholes Reservoir-nesting Caspian terns. U.S. Army Corps of Engineers Avian Predation Study Review Working Group Meeting. Walla Walla, WA, May 2007.

Good, T.P. Science underpinning Pacific salmon conservation. Cornell University Shoals Marine Laboratory. Appledore Island, ME, June 2007.

Holmes, E. E., Multivariate autoregressive modeling of multi-species time-series data. University of Washington, SAFS Quantitative Seminar. Seattle, WA, Feb 2008.

Holmes, E. E. Estimating viability parameters for metapopulations using multivariate autoregressive modeling. Ecological Society of America meeting. Milwaukee, WI, August 2008.

Holmes, E. E. Statistical estimation of community models from monitoring data. NWFSC Symposium. Seattle, WA, February 2009.

Holmes, E. E. Presentation on time series analysis. NWFSC Stats Lunch. Seattle, WA, March 2009.

Holmes, E. E. Model-selection for multivariate random walk models with hidden states. The Ecological Society Meeting. Albuquerque, NM, August 2009.

Holmes, E. E. Puget Sound Modeling forum on modeling multivariate data. Seattle, WA, 2009 (poster).

Iwamoto, E.M., and R.G. Gustafson. Examining 80 year old scales to determine if Columbia River kokanee are reservoirs of extinct sockeye salmon genetic diversity. Annual Meeting of the Western Division American Fisheries Society. Portland, OR, May 2008.

Iwamoto, E. Retention of historical genetic structure of sockeye salmon in the Wenatchee Basin despite homogenization by the Grand Coulee Fish Maintenance Project. Coastwide Salmon Genetics Meeting. Boise, ID, June 2010.

Iwamoto, E.M., and R.G. Gustafson. *Oncorhynchus nerka* transplants and their impact on kokanee population structure in the Columbia River Basin. Washington – British Columbia AFS Chapter Annual Meeting. Nanaimo, BC, March 2010.

Iwamoto, E. The Grand Coulee Fish Maintenance Project: a genetic blender or evidence for local adaptation in Columbia River sockeye salmon. 141st Annual Meeting of the American Fisheries Society. Seattle, WA, Sept 2011.

Neely, K., R. Gustafson, **E. Iwamoto,** and J. Myers. A tale from scales: Can we learn anything about the effects of climate change from reading fish scales. 141st Annual Meeting of the American Fisheries Society. Seattle, WA, Sept 2011.

Park, L., **P. Schwenke,** A. Elz, and D. Matthew. Forensic applications of molecular genetic data at the Northwest Fisheries Science Center. American Fisheries Society Annual Meeting. San Francisco, CA, September 2007. [Similar talks given at: Six Decades of Fishery Genetics symposium, Seattle, September 2007, and FDA DNA Bar-Coding Workshop College Park, MD. 2008].

Park, L., **P. Schwenke,** A. Elz, and D. Matthew. Forensics for Fisheries Enforcement. OLE General Counsel meeting. Portland, OR, June 2009.

Pollock, M., T. Beechie, and C. Jordan. Restoring incised channels and increasing streamflow in semi-arid watersheds. Ecological Society of America Conference. Portland, OR, April 2004.

Pollock, M., T. Beechie, and C. Jordan. Restoring incised channels in semi-arid watersheds of the Columbia River Basin, USA. National Conference on Ecosystem Restoration. Orlando, FL, December 2005.

Pollock, M., T. Beechie, and C. Jordan. Restoring incised channels in semi-arid watersheds of the Columbia River Basin. River Restoration Northwest Conference. Skamania, WA, February 2005.

Pollock, M., T. Beechie, and C. Jordan. Restoring incised channels in semi-arid watersheds of the Columbia River Basin, USA. American Geophysical Union Conference / North American Benthological Society Conference. New Orleans, LA, May 2005.

Pollock, M., T. Beechie, and C. Jordan. Restoring incised channels in semi-arid watersheds of the Columbia River Basin. Society of Ecological Restoration Northwest Conference. Victoria, BC, April 2005.

Pollock, M. Restoring steelhead habitat in an eastern Oregon stream by manipulating natural processes. Oregon State University Speakers Symposium. Corvallis, OR, May 2006.

Pollock, M., T. Beechie, and C. Jordan. Reconstructing a semi-arid riverine landscape. Rivers and Civilizations Conference. La Crosse, WI, June 2006.

Pollock, M. Hydrologic and geomorphic effects of beaver dams and their influence on fishes. American Fisheries Society, Oregon Chapter. Eugene, OR, February 2007.

Pollock, M., T. Beechie, and C. Jordan. Using beaver dams to restore degraded streams. Society of Ecological Restoration Northwest Conference. Yakima, WA, September 2007.

Pollock, M., and C. Jordan. Working with beaver to restore degraded riparian and stream habitat in the high desert of eastern Oregon. The Wetland Society Conference. Lincoln City, OR, February 2008.

Rhodes, L.D., S. Wallis, and S.E. Demlow. Head kidney gene expression in Chinook salmon associated with infection by attenuated or virulent *Renibacterium salmoninarum*. 49th Western fish Disease Workshop (Fish Health Section of AFS). Ocean Shores, WA, June 2008.

Rhodes, L.D., S. Wallis, and S.E. Demlow. Early response genes of Chinook salmon may be important in infection by *Renibacterium salmoninarum*. 8th International Congress on the Biology of Fish (AFS). Portland, OR, August 2008.

Rhodes, L.D., and S.E. Demlow. Chinook salmon (*Oncorhynchus tshawytscha*) have multiple interferon-gamma genes. 96th Annual Meeting of the American Association of Immunologists. Seattle, WA, May 2009 (poster).

Rhodes, L.D., S. Wallis, and S.E. Demlow. Using pathogen genetics and host response in developing vaccines against bacterial kidney disease of salmonids. Aquaculture 2010. San Diego, CA, March 2010.

Schwenke, P., A. Elz, and L. Park. NWFSC Forensic Unit Overview. NOAA Seafood Species Identification Planning Meeting. Charleston, NC, January, 2010.

Schwenke, P., A. Elz, and L. Park. NWFSC Forensic Unit marine forensics DNA. Bio-ITEST: New Frontiers in Bioinformatic and Computational Biology. Shoreline, WA, August 2011.

Schwenke, P., A. Elz, and L. Park. Forensic Science at the Northwest Fisheries Science Center. NWFSC Spring Monster Seminar Jam. Seattle, WA, June 2012.

2006 Grants

Frick, K. E., **Burke, B. J.,** and R. E. Moses. Coho salmon movements in the Lower Elwha River: Implications for recolonization following dam removal. Georgia Basin Puget Sound Research Conference. Vancouver, BC, March 2007 (Poster).

Frick, K. E., **B. J. Burke**, and M. L. McHenry. Fish responses to high flow events in the Elwha River. North Pacific International Chapter of the American Fisheries Society annual meeting. Bellingham, WA, February 2008.

Bosley, K.L., T.W. Miller, R.D. Brodeur, K.M. Cassidy, and A. Van Gaest. Feeding ecology of juvenile rockfish off Oregon and Washington as indicated by diet and stable isotope analysis. Joint Meeting of Ichthyologists and Herpetologists/Early-Life History Section of the American Fisheries Society. Portland, OR, July 2009 (poster).

Bosley, K.L., T.W. Miller, R.D. Brodeur, and A. Van Gaest. Feeding ecology of juvenile rockfish off Oregon and Washington as indicated by diet and stable isotope analysis. 15^{th} Western Groundfish Conference. Santa Cruz, CA, February 2008.

Bosley, K.L., A. Van Gaest, R.D. Brodeur, T.W. Miller, and C. Harvey. Preliminary findings from a study of juvenile rockfish feeding habits off Oregon and Washington. Oregon Chapter of the American Fisheries Society. Eugene, OR, February 2007.

Bosley, K.L., A. Van Gaest, R.D. Brodeur, T.W. Miller, and C. Harvey. Preliminary findings from a study of juvenile rockfish feeding habits off Oregon and Washington. NWFSC Science Symposium. Seattle WA, February 2007 (poster).

Morley, S.A. Effects of salmon carcasses on riverine food webs: an experimental field study on the Elwha River. 81st Annual Meeting of the Northwest Scientific Association. Seattle, WA, March 2009.

Morley, S.A. Transfer of marine-derived salmon nutrients to freshwater food webs: predicted response of primary and secondary producers to dam removal on the Elwha River, USA. 5th Annual World Fisheries Congress. Yokohama, Japan, October 2008.

Morley, S.A. Effects of salmon carcasses on riverine food webs: an experimental field study on the Elwha River. American Fisheries Society Western Division Annual Meeting. Portland, OR, May 2008.

Morley, S.A. Effects of salmon carcasses on riverine food webs: an experimental field study on the Elwha River. NWFSC Watershed Program Open House. Seattle, WA, November 2007.

Moser, M.L., S. Corbett, G. Williams, and S. Lindley. Patterns of estuary occupation by green sturgeon in Washington. National meeting of the Coastal and Estuarine Research Federation. Portland, OR, 2009 (poster).

Moser, M. L., G. Williams, S. Katz, O. Langness, S. West, J. Israel, and S. Lindley. Do green sturgeon in estuaries segregate by distinct population segment? National Meeting of the American Fisheries Society. San Francisco, CA, 2007.

Neuman, M. S. Wang, S. Lindley, **M. Moser,** and E. Mora. Development of protective regulations and critical habitat designation for the Southern DPS of green sturgeon. National Meeting of the American Fisheries Society. San Francisco, CA, 2007 (poster).

Norman, K., T. Safford, and J. Wilkinson. Managing water to support salmon recovery in Puget Sound: Institutional designs or access to scientific data? 13^{th} annual International Symposium on Society and Resource Management. Park City, UT, June 2007.

Norman, K., and T. Safford. Water for fish – water for communities: an assessment of institutional designs for managing water supplies to support salmon recovery across Puget Sound. NOAA Fisheries Social Science and Economics Workshop. Port Townsend, WA, May 2008.

Safford, T., and **K. Norman**. Science, laws and organizational networks: collaborating to implement Washington State's Salmon Recovery Act. 139th annual meeting of the American Fisheries Society. Nashville, TN, Sept. 2009.

Safford, T., and **K. Norman.** Assessing Institutional Designs for Managing Water Supplies to Support Salmon Recovery in Puget Sound. 136th annual meeting of the American Fisheries Society. Lake Placid, NY, Sept. 2006.

Sommers, F., and D. Baldwin. Avoidance of dissolved copper and utilization of structure by juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Puget Sound Georgia Basin Ecosystem Conference. Seattle, WA, February 2009 (poster).

Zabel, R.W. and K. Haught. Variability in fish size/otolith size relationships among populations of Chinook salmon. Fourth International Otolith Symposium. Monterey, CA, August 2009.

2007 Grants

Adams, N.G., P. Schwenke, and V.L. Trainer. Population structure of *Pseudo-nitzschia australis* and its association to domoic acid production in the waters of Washington State. Gordon Research Conference on Mycotoxins and Phycotoxins. New London, NH, June 2009 (poster).

Adams, N.G., P. Schwenke, and V.L. Trainer. Population structure of *Pseudo-nitzschia australis* and its association to domoic acid production in the waters of Washington State. Fifth Symposium on Harmful Algae in the U.S. Ocean Shores, WA, November 2009 (poster).

Adams, N.G., P. Schwenke, and V.L. Trainer. Population structure of *Pseudo-nitzschia australis* and its association to domoic acid production in the waters of Washington State. PICES annual meeting. Portland, OR, October 2010.

Andrews, K.S. Assessing biological response to management efforts: developing an index of growth for lingcod. Western Groundfish Conference. Santa Cruz, CA, February 2008.

Andrews, K.S. Assessing biological response to management efforts: developing an index of growth for lingcod. Western Society of Naturalists. Vancouver, BC, November 2008.

Beckman, B.R. Physiological assessment of ecosystem status and habitat quality: examples based on insulin-like growth factor 1 levels. NWFSC Science Symposium. Seattle, WA. March 2012

Berntson, E. A., E. Clarke, and L. K. Park. Deep-water coral DNA repository for the NE Pacific. American Fisheries Society. San Francisco, CA, May 2007 (poster).

Berntson, E. A., E. Clarke, and L. K. Park. Deep-water coral DNA sequence repository for species from the NE Pacific. International Deep-Sea Coral Symposium. Wellington, New Zealand, December 2008 (poster).

Berntson, E. A., E. Clarke, L. K. Park, and A. Keller. Voucher specimen collections for deep-water corals and marine fishes. NWFSC symposium. Seattle, WA, November 2009.

Berntson, E. A., E. Clarke, L. K. Park, A. Elz, C. Stehr, and A. Keller. Deep sea coral voucher project. Web presentation to the NOAA Deep Sea Coral Research and Technology Program. September 2011.

Everett, M., **E. Berntson**, A. Elz, and L. Park. Conservation genomics in the deep: discovery and application of molecular markers for deep-sea corals. National Research Council Annual Symposium. Seattle, WA, May 2013.

Everett, M., **E. Berntson**, A. Elz, and L. Park. Conservation genomics in the deep: discovery and application of molecular markers for deep-sea corals. Conservation Biology Bi-Monthly Meeting. Seattle, WA, May 2013.

Everett, M., **E. Berntson**, A. Elz, and L. Park. Genetics of deep sea coral. Seattle Aquarium Discover Science Weekend. Seattle, WA, November 2013 (poster).

Johnson, R., W. Reichert, E. Kroeger, H. Barnett, C. Carter, and M. Rust. Plasma lipid distribution and the influence of dietary lipids on plasma lipoprotein classes in vitellogenic coho salmon, *Oncorhynchus kisutch*. 32nd Fish Feed and Nutrition Workshop. Twin Falls, ID, August 2009.

Johnson, R., E. Kroeger, C. Carter, and M. Rust. The effects of elevated egg docosahexaenoic (dha) levels on tissue composition, egg and fry quality in coho salmon *Oncorhynchus kisutch*. Aquaculture America 2010. San Diego, CA, March 2010.

Johnson, R., E. Kroeger, W. Reichert, C. Carter, and M. Rust. Employing stable 13c isotopes to measure the contribution of dietary lipids to fillet lipids in market sized coho salmon *Oncorhynchus kisutch.* Aquaculture America 2011. New Orleans, LA, March 2011.

Noren, D.P., E. Jensen, D. Boyd, and G. Ylitalo. The dynamics of persistent organic pollutant (POP) transfer from female bottlenose dolphins (*Tursiops trucatus*) to their offspring during gestation and lactation. 19th Biennial Conference on the Biology of Marine Mammals. Tampa, FL, November/December 2011 (poster).

2009 Grants

Flitcroft, R., K.M. Burnett, **A.H. Fullerton**, and N. Som. Toward a framework for characterizing hydrologic connectivity in riverine fishes. American Fisheries Society annual meeting. Seattle, WA, September 2011.

Fullerton, A.H. and R. Zabel. Conserving metapopulation structure for Pacific salmon may counteract forces acting to increase synchrony. North American Chapter of the Society for Conservation Biology. Oakland, CA, July 2012.

Fullerton, A., G.Pess, S. Lindley, and R. Zabel. Prioritizing which salmon populations to re-establish: we opened it, now how long will it take? American Fisheries Society annual meeting. Seattle, WA, September 2011.

Fullerton, A., C. Torgersen, J. Lawler, and A. Steel. Can spatial heterogeneity mediate altered thermal regimes for juvenile salmon? American Fisheries Society annual meeting. Seattle, WA, September 2011.

Fullerton A., S. Lindley, G. Pess, B. Feist, A. Steel and P. McElhany. Human influence on the spatial structure of threatened Pacific salmon metapopulations. International Association of Landscape Ecology. Portland, OR, April 2011.

Fullerton, A.H., S.T. Lindley, G.R. Pess, B.E. Feist, E.A. Steel, and P. McElhany. Investigating connectivity among Pacific salmonid populations under alternative scenarios: a graph-theoretic approach. American Fisheries Society Annual Meeting. Pittsburgh, PA, September 2010.

Fullerton, A.H., S.T. Lindley, G.R. Pess, B.E. Feist and P. McElhany. Do Hatcheries Influence the spatial structure of salmon populations? State of the Salmon Conference. Portland OR, May 2010.

Fullerton, A.H., K.M. Burnett, B.E. Feist, R.L. Flitcroft, P. McElhany, D.J. Miller, G. Pess, B.L. Sanderson, E.A. Steel, and C.E. Torgersen. Connectivity in freshwater ecosystems: a literature synthesis and an example conservation application. Oregon Chapter American Fisheries Society meeting. Bend, OR, February 2009.

Fullerton, A.H., R. Flitcroft, G. Pess, A. Steel, B. Feist, B. Sanderson, D. Miller, and C. Torgersen. Interpreting aquatic connectivity: a challenge and an opportunity. North Pacific International Chapter American Fisheries Society annual meeting. Bellingham, WA, March 2008.

Good, T. P., and G. Ylitalo. Pick your poison: persistent organic pollutants in rhinoceros auklet prey at breeding colonies. Pacific Seabird Group. Turtle Bay, HI, February 2012.

Good, T. P., G. Ylitalo, S. Pearson, P. Hodum, J. Parrish, and M Schrimpf. Patterns in seabird diet and persistent organic pollutants in Puget Sound forage fish. Study Panel on Ecosystem-based Management of Forage Fish. University of Washington Friday Harbor Laboratory. San Juan Island, WA, August 2013.

Snow, S., and **A.H. Fullerton.** Evaluating habitat availability, connectivity, and use by Pacific Salmon. NOAA Hollings Scholar Program. Silver Spring, MD, August 2008.

Steel, E.A. Riverine Thermal Regimes: Human alterations and biological consequences. Institut für Hydrobiologie und Gewässermanagement, Department Wasser - Atmosphäre – Umwelt, BOKU - Universität für Bodenkultur. Vienna, Austria, May 2010.

Steel, E.A. Riverine thermal regimes: Human alterations and biological consequences. Oregon Chapter, American Fisheries Society Annual Meeting. Bend, OR, April 2009.

Steel, E.A. Stream temperature variability over time and space. The International Environmetrics Society. Anchorage, AK, June 2013 (invited).

Steel, E.A., A. Fullerton, B. Beckman, and S. Luis. Human alterations to riverine thermal regimes and biological consequences. Puget Sound Georgia Basin Ecosystem Conference. Seattle, WA, February 2009.

Steel, E.A., K. Hanson, T. Beechie, I. Lange, D. Larson, A. Fullerton, K. Denton, A. Tillotson, and B. Beckman. Riverine Thermal regimes: human alterations and biological consequences. Institut für Hydrobiologie und Gewässermanagement, Department Wasser - Atmosphäre – Umwelt, BOKU - Universität für Bodenkultur. Vienna, Austria, May, 2010.

Steel, E.A., D. Larsen, A. Fullerton, K. Denton, A. Tillotson, and B. Beckman. Experiments on altered thermal regimes during early life stages of Chinook salmon. American Fisheries Society annual meeting. Seattle, WA, September 2011.

Steel, E.A., D. Larsen, A. Fullerton, K. Denton, A. Tillotson, and B. Beckman. Experiments on altered thermal regimes during early life stages of Chinook salmon. Salish Sea Ecosystem Conference. Vancouver, BC, October 2011.

Tillotson, A., **E.A. Steel,** B. Beckman, D. Larsen, A.H. Fullerton, and K. Denton. The variable family response of emergence timing for spring Chinook salmon eggs incubated under different thermal regimes. American Fisheries Society annual meeting. Seattle, WA, September 2011.

2010 Grants

Andrews, K.S. Jellies on the move: vertical and horizontal patterns of movement. Western Society of Naturalists Annual Meeting. San Diego, CA, November 2010.

Andrews, K.S. Jellies on the move: vertical and horizontal patterns of movement. Puget Sound Biotelemetry Annual Meeting. Seattle, WA, February 2011.

Chittaro, P.M., B. Anulacion, and R.W. Zabel. Suitability of somatic growth of English sole as an ecosystem indicator. Salish Sea Conference. Vancouver, BC, October 2011.

Corbett, S., B. Feist, S. Lindley, and **M. Moser**. Temporal and spatial patterns of feeding by green sturgeon in a Washington estuary. World Sturgeon Conference. Nanaimo, BC, 2011 (poser).

Doctor, K.K., B. Berejikian, R. Endicott, R. Endicott, and J. Lee-Waltermire. Local adaptation in Hood Canal Steelhead? Genetic variability in reaction norms for early life history traits between two populations. American Fisheries Society annual meeting. Seattle, WA, September 2011.

Doctor, K.K., B. Berejikian, R. Endicott, E. Ward, and J. Hard. Local adaptation in Hood Canal Steelhead? The role of genetics and temperature on early growth and smoltification. American Fisheries Society Washington-British Columbia Chapter meeting. Victoria, BC, May 2012.

Jorgensen, J.C., V.L. Butler, H.R. Huber, and D. Yang. Getting into shape: a simple, rapid, and low-cost method to identify Pacific salmonid (*Oncorhynchus* spp.) vertebrae to species. American Geophysical Union Chapman Conference: Past Landscapes, Climate, Civilizations. Santa Fe, NM, March 2011.

Luckenbach, J.A. and W.T. Fairgrieve. Characterization of normal gonadal sex differentiation in sablefish and effects of dietary 17 alpha-methyltestosterone on gonadal development. 15th Annual Center for Reproductive Biology retreat. Pullman, WA, May 2011.

Luckenbach, J.A., E.K. Smith, and P. Swanson. From candidate genes to RNA-seq: Rapid advancement of molecular techniques to study reproductive physiology in non-model fishes. 82nd Meeting of the Zoological Society of Japan. Asahikawa, Japan, September 2011.

Luckenbach, J.A., and W.T. Fairgrieve. Characterization of sexual differentiation and development of methods for sex control in sablefish, *Anoplopoma fimbria*. 3rd NWFSC Science Symposium. Seattle, WA, March 2012.

Luckenbach, J.A., and W.T. Fairgrieve. Characterization of normal gonadal sex differentiation in sablefish *Anoplopoma fimbria* and effects of dietary 17 alpha-methyltestosterone. Aquaculture America conference. Las Vegas, NV, March 2012.

Luckenbach J.A., E.K. Smith, and W.T. Fairgrieve. Molecular sex differentiation and strategies for sex control in sablefish *Anoplopoma fimbria*. Aquaculture 2013 conference. Nashville, TN, February 2013.

Moriarty, P., **K. Andrews,** and **C. Harvey.** Movement patterns of scyphozoan jellyfish in Puget Sound. NOAA Hollings Scholar Presentations. Silver Spring, MD, August 2010.

Moser, M., S. Corbett, K. Patten, B. Feist, and S. Lindley. Patterns of green sturgeon feeding in Washington estuaries. WA-BC Chapter of the American Fisheries Society. Nanaimo, BC, 2010.

Moser, M. Barbleheads unite: Developing an acoustic monitoring network for green sturgeon on the West Coast of North America. National meeting of American Fisheries Society. St. Paul, MN, 2012 (invited).

Moser, M., S. Corbett, K. Patten, B. Feist, and S. Lindley. Characterization of green sturgeon feeding habitat in Willapa Bay, Washington. Gilbert Ichthyological Society. Seabeck, WA, 2012.

Rhodes, L.D., and **A.E. Baxter**. Microbial features in a marine bay with chronic low dissolved oxygen. Keystone Symposium: Microbial Communities as Drivers of Ecosystem Diversity. Breckenridge, CO, March 2011.

Rhodes, L.D., **A.E. Baxter,** and D.D. Berman. Profiling microbial features in a Whidbey Basin bay with low dissolved oxygen. Salish Sea Ecosystem Conference. Vancouver, BC, October 2011.

Rhodes, L.D. **A.E. Baxter**, and D.D. Berman. Looking closer to home: microbial ecology studies in Puget Sound. Oceans & Human Health Joint Seminar Series. Seattle, WA, November 2011.

2011 Grants

Frick, K.E., S. Brenkman, R. Moses, and J. McMillan. Adult salmon movements in previously inaccessible habitat in the Elwha River. Northwest Fisheries Science Center Science Symposium. Seattle, WA, March 2012 (Poster).

Laetz, C.A., D.H. Baldwin and N.L. Scholz. The neurological and behavioral effects of pesticide mixtures to juvenile coho salmon. American Fisheries Society annual meeting. Seattle, WA, September 2011.

Laetz, C.A. Elevated temperature enhances the synergistic toxicity of pesticide mixtures to juvenile salmon. Ecotoxicology program meeting. Seattle, WA, September 2011.

Laetz, C.A., D.H. Baldwin, J. Stark, and N.L. Scholz. Elevated temperature enhances the toxicity of pesticide mixtures to juvenile coho salmon. American Water Resources Association summer meeting, Contaminants of Emerging Concern. Denver, CO, June 2012.

Sanderson, B.L. Predation by smallmouth bass, walleye, and other native and non-native species in the Pacific NW. NW Power and Conservation Council Science-Policy exchange on role of predation and predator control actions in the Columbia River Basin. Portland, OR, August 2012.

Sanderson, B.L., and E. Buhle. Nonnative species in the Pacific Northwest. Independent Scientific Advisory Board. Portland, OR, November 2013.

Sanderson, B.L. Welcome or unwelcome guests? Our complex relationship with nonnative sport fishes. Columbia Basin non-native invasive fish species Symposium. Spokane, WA, November 2013.

Appendix E

List of Miscellaneous Products of Research Funded by the NWFSC Internal Grants Program

The PI(s) and year of award are shown in bold at the end of each entry.

The sediment supply model has been applied to many ESA-listed salmon populations for both recovery planning and the development of NMFS Biological Opinions; this approach has also become one element of a broader approach to ecosystem recovery planning for listed salmon **(Beechie, 2001)**.

We identified the Coho salmon equivalent of the goldfish and zebrafish basic amino acid receptor for olfaction and homing. The receptors are now being used as markers of imprinting success for several ongoing studies of salmon straying (**Dittman, 2001)**.

The patterns of Chinook salmon life history diversity emerging in the Skagit River Basin have been used to specify diversity goals in the Skagit River Basin Recovery Plan and more generally in the Puget Sound Salmon Recovery Plan for ESA listed salmon (**Levin, 2001**).

A zebrafish breeding colony capable of housing up to 1000 adult fish was installed, and the expertise for husbandry developed. The colony has run flawlessly, and we have succeeded in maintaining the colony through at least 6 generations of wild-type fish (**Scholz, 2001**).

The diagnostic molecular assay for *R. salmoninarum* we developed is applied by researchers at US Fish & Wildlife Service, US Geological Survey, and NOAA Fisheries (**Rhodes, 2001**).

We organized a 2-week field course (three teams per summer, 6-8 volunteers/team) introducing high school students, teachers, and volunteers to riparian and stream ecology, fish biology, ornithology, entomology, geomorphology, forest ecology, conservation biology, and management of threatened and endangered salmonid species. These field courses were conducted in the Skagit River basin with IGP funding as well as support from Earthwatch (**Kiffney, 2002**).

Information developed as part of our IGP-funded research has been used in restoration planning across Puget Sound, including identifying critical habitats for Pacific salmon (**Kiffney, 2002**)

We found that *Spartina* is a major contributor of organic matter to Willapa Bay, and it is likely to have far reaching impacts even in estuaries where it has not invaded (i.e., Grays Harbor) (**Feist, 2002**).

Tools developed under our IGP project have been used for several years to monitor, in archived and fresh plasma samples, the rate of precocious male maturation at the Yakima Supplementation Hatchery and revealed that approximately 50% of the male spring Chinook released from this facility each year precociously mature at age-2. These tools are also being employed to monitor precocious male maturation rates in wild Yakima spring Chinook and in laboratory based studies aimed at designing rearing regimes to control high rates of precocious male maturation in hatchery stocks and captive broodstock populations (**Larsen, 2002**).

Groundwork demonstrating the feasibility of extracting DNA from archived scales has made feasible two advanced-degree projects at the University of Washington, involving Columbia River sockeye salmon and kokanee and Puget Sound coho salmon (**Myers, 2002**).

Aided by IGP-funded research, we have developed a comprehensive ecosystem monitoring plan for the Elwha River (**Pess, 2002**).

We determined that plasma IGF-I values may be used to assess relative growth of salmon, even if the salmon were obtained from water with differing temperatures. This is the first time someone has been able provide an index of instantaneous growth in ocean dwelling salmon and then compared that relative growth rate to survival (**Beckman, 2003**).

One IGP project produced the following: 1) A publication was featured in Coastal and Estuarine Science News and by the Puget Sound Institute for its relevance to coastal management. 2) a poster was awarded Best Professional Water Quality Poster at the 2005 national meeting of the American Fisheries Society. 3) A detailed GIS data layer of nearshore habitat condition along the entire length of the Duwamish was shared with Seattle Public Utilities and made publicly available to other researchers focusing on Puget Sound shoreline management (**Morley, 2003**).

Another project accomplished the following: 1) Successful proof-of-concept provided justification to purchase a new vessel, new hydroacoustic equipment, new field computers, and software to develop hydroacoustic program for the lower Columbia estuary ($235K value). 2) A 38 kHz hydroacoustic transducer for mapping fish distribution and abundance in lower Columbia River was installed in a NOAA research vessel. 3) We collected preliminary data using hydroacoustics to map distribution of threatened Columbia River smelt (*Thaleichthys pacificus*). 4) We convened a joint State-Federal Forage Fish Workshop at Pt. Adams Research Station (**Zamon, 2003**).

The incredible success at re-locating ("re-capturing") green sturgeon tagged with acoustic transmitters has raised the possibility that we could estimate age/size-based survival estimates for this species (**Moser, 2003**).

Our study has spawned additional products for monitoring: 1) A comparison of fish habitat utilization in the Snohomish River delta. 2) The study was used as an example of mark-and-recapture studies proposed as part of a 10-year monitoring grant examining benefits of restoration in the Skagit River delta. This grant was funded for $220K per year, with $30K earmarked for mark-recapture studies (**Greene, 2004**).

The coho ELISA assay that has been developed has taken immediate precedence within this project, since there are two other ongoing projects within our Division that require this assay as a tool (**Peck-Miller, 2004**).

Our study of genetics and phenetics of rainbow trout above the Howard Hansen Dam stimulated interest in other comparable scenarios in the Pacific Northwest, including Icicle Creek in the Wenatchee River; three dams on the Lewis River; Condit Dam on the White Salmon River; two dams on the Sandy River; and two dams on the Elwha River. Genetic research at these sites has generated several research grants and publications (**Winans, 2004**).

We used our grant to develop workshops to train scientists in the analysis of population data and risk assessment. Workshops were given at the 2004, 2005, 2007, 2008, 2010, 2011, and 2012 Ecological Society of America National Meetings, at the 2009 Biennial Marine Mammal Conference, and in 2007 at the National Center for Ecological Analysis and Synthesis. All workshop are online via a web content manager developed with the Internal Grant. Over 250 scientists have been trained (**Holmes, 2005**).

Open source software, LAMBDA and MARSS, for analysis of population time-series data was developed and released. MARSS is hosted on CRAN and as of June 2012 is downloaded approximately 1000 times each month and used by scientists in the environmental sciences, finance, economics, and the social sciences (**Holmes, 2005**).

As a result of our project, 1304 specimens vouchered and 784 specimens from 276 species were sequenced for DNA. These data are publicly available in Genbank and the Barcode of Life database (BOLD). Specimens and data collected as part of this project are regularly used by other researchers, and have been used by the NOAA Office of Law Enforcement for species identification of alleged mislabeled seafood (**Schwenke, 2005**).

We have developed a map of elemental isotope ratios and concentrations throughout the Snake River basin for use in otolith microchemistry studies (**Zabel, 2006**).

We initiated a winter-run steelhead tracking study in 2007, using the pre-installed equipment from our 2006 project on coho salmon. Subsequently, this general approach has been expanded to include analysis of Chinook salmon and bull trout, in collaboration with the Lower Elwha-Klallam tribe and the U.S. National Park Service (**Burke, 2006**).

The acoustic detection data from our project were used extensively in the 2008 NMFS designation of Critical Habitat for the ESA-listed southern population of green sturgeon (**Moser, 2006**).

Based on results of our study, we organized special sessions on the influence of humans on aquatic connectivity for the 2011 annual meetings of the US Chapter of the International Association for Landscape Ecology (Portland, OR); and the American Fisheries Society (Seattle). The US-IALE session had 11 speakers from 3 countries, and the AFS session had 21 speakers from 6 countries (**Fullerton, 2009**).

Data emanating from this project were used in development of the Recovery Plan for the ESA-listed southern population of green sturgeon (**Moser, 2010)**.

Microbial ecology work conducted during our project has led to inclusion of microbial analyses in projects with a primary focus on finfish, foodwebs, and watershed remediation. The PI is now also a participant in a Marine Microbes Working Group, which is led by NOAA's Office of Ocean Exploration & Research. This working group is one component of OER's Living Marine Resources project on marine microbes to integrate marine microbiology into ecosystem research across line offices (**Rhodes, 2010**) (http://explore.noaa.gov/Science/LivingMarineResources.aspx).

Data generated during our project were used to inform on-going Endangered Species Act consultations between NMFS Office of Protected Resources and the Environmental Protection Agency (EPA) regarding the effects of pesticides on Pacific salmonids. The consultations are in response to both litigation settlements and EPA’s national pesticide registration process (**Laetz, 2011**).

Appendix F

Summary of Management Applications of Research Funded by the NWFSC Internal Grants Program

Please see summaries in the main text for the following projects: **Rapid phenotypic screening in zebrafish** (Nat Scholz and John Incardona, 2001); **Validating plasma IGF1 levels as a growth indicator for juvenile salmon** (Brian Beckman, 2003); **Estimating Caspian tern predation on juvenile salmonids in the Mid-Columbia River** (Tom Good, 2005); **Use of acoustic telemetry to document green sturgeon movements in estuaries** (Mary Moser, 2003, 2006, 2010).

Testing tools for science-based recovery planning: sensitivity analyses of a decision support system and application to restoration of watersheds containing ESA-listed Pacific salmonids
Researcher: Aimee Fullerton, 2005

This project expanded on a case study commissioned by the Willamette-Lower Columbia Technical Recovery Team to develop a decision-support tool consisting of multiple models for recovery planning. This project critically evaluated model performance in several different ways, producing 3 papers that have direct management relevance to recovery planning and improved decision making for Pacific salmonids. The first (Fullerton et al. 2009, Ecol. Appl. 19:218-235) evaluated multiple habitat management strategies under a variety of alternative future scenarios. The second (Fullerton et al. 2010, Env. Mod. & Assmt. 15:13-26) evaluated the sensitivity of model predictions to parameter perturbation, and compared predictions to empirical field data. The third (Fullerton et al. 2010, Rest. Ecol. 18(S2):354-369) evaluated how economics and spatial configuration might influence decisions about where to place habitat restoration projects to improve fish population performance. The papers that we produced have generated interest in applying these concepts to local recovery planning efforts. We received inquiries from the Puyallup Watershed Council, the Independent Scientific Advisory Board, The Nature Conservancy, and the Skagit River Cooperative, among others. Clark County used some of our GIS data in their Shoreline Master Program Inventory and Characterization. Additionally, some of the models developed as part of this project were used to provide habitat-based estimates of capacity and survival for life cycle modeling to support the biological opinion for multiyear harvest planning for fall Chinook salmon in the Lower Columbia River, 2009.

Landscape structure versus content: impacts of large-scale land use on salmon and their habitats
Researcher: Ashley Steel, 2005

We were able to quantify differences in the strength of species habitat relationships across geographic scales. These models provide insights into mechanisms that drive these relationships and guidance for designing *in situ* monitoring programs, conservation efforts, and mechanistic studies. There is no single 'best' extent over which to summarize landscape condition. The spatial window size over which we summarize or examine habitat variables can be important. Our analyses indicate that coarse-grained land use and land cover predictor variables do not correlate as well with Pacific salmon redd density when summarized within 500 m of the stream channel. Much stream and river research has been conducted at the reach scale, and often restoration or land-use decisions focus only on the riparian buffer surrounding a stream. That the pattern of land-use across the entire catchment might be as strongly or even more strongly associated with stream condition or salmon distribution is useful for conceptualizing the scale of required restoration efforts. Our results open the way for tools from the field of landscape ecology to be applied to river and salmon conservation.

Coho salmon behavior in the Elwha River: Implications for recolonization after dam removal
Researcher: Brian Burke, 2006

This study focused on the movement of adult coho salmon in the lower portions of the Elwha River, downstream of Elwha Dam. This population of coho salmon is dominated by hatchery releases and was limited to only the lower five miles of the River. The work was, however, envisioned as the first stage in developing a river-wide system of antennas that would be used to assess the distribution of adult spawners throughout the river, including areas located in Olympic National Park. The study demonstrated that the movements of coho in the lower river were fairly limited spatially and that affinity for the hatchery was high. This result was not really surprising; however, it did influence later decisions to move adult coho from the lower river hatcheries to upstream tributaries. In 2011, the decision was made to experimentally relocate ~600 coho to the mainstem Elwha just above Aldwell reservoir. Ten percent of these fish were radio tagged. Half of these fish actually dropped back to the lower river, affirming their affinity for the lower river hatcheries. Additional releases were made in 2012 (350 adults) and 2013 (1120 adults), but this time directly to the middle river tributaries (Little River and Indian Creek). These releases have been very successful, with high rates of retention within the system and successful spawning. This study helped the Lower Elwha Tribe gain expertise in radio telemetry techniques and this has empowered them to be full partners with other agencies and organizations, including Olympic National Park.

Development of risk assessment software and training for analysis of population count data
Researcher: Eli Holmes, 2005

The 2005 internal grant funded a prototype of a content-management platform for sharing NOAA software and code. The completed platform, now called FishBox, has been approved by NOAA and is now hosted at NWFSC (https://fishbox.nwfsc.noaa.gov/). This provides a secure NOAA platform for sharing NOAA developed tools. In 2013, Eli Holmes and Eric Ward were asked to help developed a NOAA Protected Species Toolbox (NPST) similar in spirit to the highly successful NOAA Fisheries Toolbox. NPST would host statistical and modeling tools for protected species across the NMFS science centers. FishBox allowed us to compete successfully for funding to develop and host the prototype Protected Species Toolbox—not only because it showed our expertise in this area, but also because NPST will use a duplicate of the FishBox architecture and thus we were able to rapidly develop a prototype.

The dynamics of persistent organic pollutant (POP) transfer from female cetaceans to their offspring during gestation and lactation
Researcher: Dawn Noren, 2007

The purpose of this study was to assess the dynamics of the transfer of persistent organic pollutants (POPs) from female dolphins to their young during gestation and lactation. POPs are lipophilic compounds that can accumulate in relatively high concentrations in the blubber layer of marine mammals, which are long-lived, top-level predators in their ecosystem. These compounds, which include DDTs, PCBs, and PBDEs, have been linked to reduced immune system efficiency and reproductive failure in pinnipeds. Although the dynamics of POP transfer have been studied in some pinniped species, there have been no such studies in cetaceans. Due to the differences in life history strategies and behavior in lactating pinnipeds compared to dolphins, a study on contaminant transfer in a dolphin species was warranted. This is important for assessing risk from contaminant exposure in young dolphins and provides critical data for one of the key risk factors (contaminant exposure) identified for the endangered Southern Resident killer whale population.

Funding by the IGP and generosity from the U.S. Navy Marine Mammal Program provided sufficient blood and milk samples from female-calf pairs to determine the general pattern of contaminant transfer from mothers to their calves in bottlenose dolphins. Transfer dynamics in dolphins differed from that of previously studied marine mammals (seals). Thus, this study produced novel results that have not yet been observed in marine mammals studied to date. The PI presented results at an international conference on Marine Mammals in 2011 and was invited to present results to the working group on “Toxicological Thresholds for the Protection of Southern Resident Killer Whales” hosted by the NOAA Northwest Regional Office in April 2013. Some findings from the study will also be reported in a NOAA Technical Memorandum produced by the NOAA West Coast Regional Office and at least one manuscript will be prepared for submission to a peer-reviewed journal.

From experiments to landscapes: physiological, behavioral, and ecological consequences of anthropogenically altered thermal regimes during Chinook salmon incubation
Researcher: Ashley Steel, 2008

Our results indicate that the commonly-used degree-day-accumulation model is not sufficient to predict how organisms respond to altered temperature regimes. Therefore, changes in thermal variability, independent of warming, have the potential to alter the timing of life history processes in Chinook salmon and potentially other organisms. As well, there are likely to be genetic differences in how individuals and populations respond to future water temperature regimes. The ecological implications of altered life history timing or of development stage at emergence for Chinook salmon and for aquatic communities are far-reaching. Emerging a few days earlier or a few days later may directly impact survival by changing available food resources at emergence, altering environmental conditions, e.g., flow, at emergence, or shifting the timing of later life history transitions

Use of these findings:

- Decision-makers need to identify priorities for freshwater restoration and conservation. Such planning often considers spatial heterogeneity in water temperatures, basing priorities on mean temperatures. Our results open the door to incorporating changing variability of water temperature regimes, as predicted under future climates, in conservation and restoration planning.
- Landscape models to predict future species distributions often use 'climate envelopes' that include thermal means, precipitation, and seasonality. Our findings indicate that incorporating predicted future changes in thermal variability may improve our estimates of future species distributions.
- Our results can be applied to the management of hydropower operations, wetland mitigation, and riparian forest management. These kinds of management decisions can be improved by considering the natural temperature regime in its full complexity, rather than only lethal thresholds or total temperature units delivered in a given period of time.
- Monitoring freshwater temperature is essential for managing fishes and other aquatic organisms. Our results can be applied to improve the monitoring of water temperature regimes by providing rationale for storing and archiving hourly information where it is collected instead of simply storing mean or maximum daily temperature.
- There may be an opportunity to improve fisheries management during a changing climate. Our results suggest that some populations or even families may be genetically pre-disposed to respond or not respond to future changes in thermal regimes. Such genetic predispositions could lead to increased risk of population declines and/or opportunities for adaptation and could be used to refine hatchery and supplementation programs, particularly for listed and endangered species.

Using measures of freshwater habitat connectivity for conservation planning
Researcher: Aimee Fullerton, 2009

This project was developed to provide information about how the spatial arrangement of habitat relates to the spatial structure of salmon populations. Although spatial structure is one of the 4 viable salmonid population parameters, we arguably understand it less well than the other 3 (abundance, productivity, and diversity). This work, combined with efforts from the SWFSC, has since been applied to evaluate the spatial structure of several salmon species in the Willamette-Lower Columbia and more recently to inform life cycle modeling for Snake River Chinook salmon, called for by the Adaptive Management Implementation Plan of the 2008 FRCPS BiOp. During development of analytical approaches, we also completed a literature review that has been well-cited (>50 times to date), and convened 2 special sessions at national conferences to discuss the topic of connectivity in aquatic environments.

Nonnative predators in Columbia River reservoirs
Researchers: Beth Sanderson and Matt Nesbit, 2011

Since the late 1800s, over 20 species of nonnative predatory fish have been intentionally introduced into the Columbia River basin for recreational purposes. Although the rate of introductions by federal and state agencies has declined, many nonnative game fishes now inhabit the majority of watersheds in Washington, Oregon, and Idaho. In this region where healthy game fish populations may be at odds with ESA-listed salmonids, there is great resistance to discussions about the role of recreational game fishes in these ecosystems and implications for threatened and endangered species. Funding from the Internal Grants Program has provided us the opportunity to speak at several scientific meetings about the research we are doing. We have presented the goals and design of the project to the Independent Scientific Advisory Board and the NW Power and Conservation Council, and at a regional symposium on Columbia Basin nonnative invasive fish species. In both cases, we have placed our small study in the context of broader regional questions. In doing so, we hope that information brought to light about how nonnative predators behave in relation to juvenile salmonid migrations will inform and lead to changes in management practices regarding nonnative species.

Appendix G

Proposal Guidelines and Sample Reviewer Score Sheets for the NWFSC Internal Grants Program

Below are the Guidelines for Final Proposals and reviewer score sheets for the NWFSC Internal Grants Program. These are provided only as examples; ideally, those considering implementing a program of this type should develop guidelines and practices that are most likely to achieve program objectives.

Guidelines for Final Proposals

General

Be aware that although your proposal will be reviewed by an outside scientist with appropriate expertise, it will also be reviewed and evaluated by Panel members who are not experts in your particular field. This means that your proposal will have to communicate effectively to a general scientific audience. It is in your best interest to avoid unnecessary jargon and to clearly define specialized terms that you do use.

Please submit the entire package as a single Word file. Budgets, CVs, Figures, etc. should if possible be pasted into the Word document. This will facilitate handling, copying, and editing by staff. **Use 12 point or larger type and 1 inch margins throughout**.

Color figures and color pages are expensive and time consuming to duplicate. If you must use color figures, by the proposal deadline please provide Diane Tierney with 12 complete hard copies of your proposal, for distribution to Review Panel members.

COVER PAGE

Title
PI(s) and Collaborators
Track (Junior or Open)
Amount of funding requested for each fiscal year
Project start and end dates
Key words and phrases (to facilitate tracking in a database)

SUMMARY: 0.5 page*

STATEMENT OF RESEARCH QUESTION AND WHY IT IS IMPORTANT: 1 page*

METHODS AND RESEARCH PLAN: 3 pages*

[Note: if any permits are required to conduct proposed research (e.g., for an ESA-listed population), the applicant should demonstrate here that the necessary permits have been or will be granted.]

EXPECTED DIFFICULTIES: 0.5 page*

STATEMENT EXPLAINING WHY THE PROPOSED RESEARCH MEETS THE GUIDELINES DEVELOPED FOR THE INTERNAL GRANTS PROGRAM: 1 page*

Be sure to include a statement why the proposed research is important *to the PI*. This is obviously important for junior PIs but is no less important for senior PIs, who often end up managing science more than doing it. PIs who receive awards in the Open Track should be intimately involved in the research, even if significant portions of the work are done by others.

EXPLANATION OF THE ROLES OF EACH PI AND MAJOR COLLABORATOR: 0.5 page*

EXPLANATION OF CURRENT RESPONSIBILITIES AND OPPORTUNITIES FOR PEER-REVIEWED PUBLICATIONS OVER LAST 3-5 YEARS: 0.5 page*

TABLES AND FIGURES: 2 pages total*

KEY REFERENCES: 1 page*

BUDGET: 1 page*

If NMFS salaries are included, to estimate cost use base salary + 27.5%. Example:

Staff Salaries	**Pay Periods**		**Base Salary**
Fish Bio Band X, step Y	5	10,000	
	Benefits (27.5% of base)		2,750
		Total labor cost	12,750

Within the one-page limit, include a brief explanation/justification for major budget items.

VITA FOR EACH PI (2-3 pages maximum per PI). Report 'selected publications' ONLY if you have too many to list them all; in that case, the emphasis should be on recent publications.

PRIOR FUNDING: 0.5 page*

For projects externally funded during the past 5 years, list type and amount of funding, title of project funded, and resulting publications. Indicate previous attempts to fund the work externally.

If you previously received a grant through the Center's Internal Grants Program, your proposal will not be accepted unless you have filed a completion report. If the previously funded research is still ongoing, briefly summarize (1 page max) the important results, publications, presentations, and any new funding generated or new research inspired by the results, and include this information at the end of your proposal application (this information does not count in your page limits).

PREVIOUS APPLICANTS WITH UNFUNDED PROPOSALS: 0.5 page*

If your proposal is related to one that was submitted to the Internal Grants Program in a previous year but not funded, please provide a short explanation of the relationship of the current proposal to the previous one and how you have responded to reviewer comments. This is a crucial part of the application for resubmitted proposals. If the proposal might be confused with one submitted in an earlier year but in reality is a totally different proposal, please include a short note to that effect.

Entire proposal should be single-spaced in 12-point type. * Page limits are maxima for each category. Panel may decline to review additional pages.

Internal NWFSC Grants Program

Proposal Evaluation Form (Internal NWFSC reviewer)
(use as much space as needed for each question to explain the score)

1. **IMPORTANCE OF QUESTION**: How important is the question being asked, both to the Center's mission and research plan and to the broader scientific community? What is the expected significance and contribution of the results? <u>5 Points maximum</u>

2. **SCIENTIFIC QUALITY AND ORIGINALITY OF METHODS/APPROACH:** Are the methods appropriate and well-reasoned? Is the approach novel in any way? Is there evidence of realistic anticipation of difficulties that need to be overcome, and some thought on how to deal with contingencies? <u>10 Points maximum</u>

3. **IS THE PROPOSED RESEARCH UNLIKELY TO BE FUNDED BY OTHER MEANS, YET IF SUCCESSFUL LEAD TO IMPORTANT INSIGHTS OR PRODUCTIVE LINES OF FUTURE INQUIRY?** Does the proposed research fall within the scope of projects this program is designed to promote? <u>5 Points maximum</u>

4. **DO THE VITAS INDICATE HIGH LEVELS OF SCIENTIFIC PRODUCTIVITY OVER THE LAST 2-4 YEARS?** See Program Guidelines for discussion. <u>5 Points maximum</u>

Scale: For elements 1, 3, 4: 5 = excellent, 4 = very good, 3 = good, 2 = fair, 1 = poor. Double these to get the scale for Element #2. Please provide supporting prose explaining the rationale for each element.

All proposals will be evaluated for scientific quality on the same absolute scale, as described above. The Panel will consider other factors (e.g., seniority, research opportunities, previous funding, etc.) along with the reviewer scores in evaluating the proposals. After considering the proposals as a whole in the overall context of the Center's mission, the goals of the Internal Grants Program, and available funds, the Panel will make a recommendation to the Center Director about which proposals to fund.

NWFSC Internal Grants Program

Proposal Evaluation Form (External reviewer)

Please provide a score as indicated for each element below, as well as supporting text. The maximum number of pages allowed in the proposal for each element is shown in brackets. Candid but constructive comments will be of most benefit to the program and the applicants. As you prepare your review, please keep the following points in mind:

- The Center's Internal Grants Program has multiple goals, as articulated in the guidance document (attached). Please refer to this document if you would like more information about the program.
- Although we have established a separate track for more junior scientists, all proposals are evaluated against the same scientific standard. Therefore, please evaluate the proposals on a single scale of quality, with the highest scores being roughly equivalent to what you would expect in a high-quality NSF, NIH, or similar proposal. The review panel will take experience and other factors into consideration in making recommendations for awards.
- Note that the two elements have different maxima for number of points
- Use as much space as needed to explain your assessment of each element

1. **IMPORTANCE OF QUESTION**: How important is the question being asked to the broader scientific community? What is the expected significance and contribution of the results? (1 page) (<u>10 points Maximum</u>)

2. **SCIENTIFIC QUALITY AND ORIGINALITY OF METHODS/APPROACH:** Are the methods appropriate and well-reasoned? Is the approach novel in any way? Is there evidence of realistic anticipation of difficulties that need to be overcome, and some thought on how to deal with contingencies? (3 pages) (<u>15 points Maximum</u>)

Total points (25 maximum) ____________________

Recent NOAA Technical Memorandums

published by the

Northwest Fisheries Science Center

NOAA Technical Memorandum NMFS-NWFSC-

130 **Puget Sound Recovery Implementation Technical Team. 2015.** Puget Sound Chinook salmon recovery: A framework for the development of monitoring and adaptive management plans. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-130, 146 p. NTIS number PB2016-100691. doi:10.7289/V5/TM-NWFSC-130.

129 **Hard, J.J., J.M. Myers, E.J. Connor, R.A. Hayman, R.G. Kope, G. Lucchetti, A.R. Marshall, G.R. Pess, and B.E. Thompson. 2015.** Viability criteria for steelhead within the Puget Sound distinct population segment. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-129, 332 p. NTIS number PB2015-105188. doi:10.7289/V5/TM-NWFSC-129.

128 **Myers, J.M., J.J. Hard, E.J. Connor, R.A. Hayman, R.G. Kope, G. Lucchetti, A.R. Marshall, G.R. Pess, and B.E. Thompson. 2015.** Identifying historical populations of steelhead within the Puget Sound distinct population segment. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-128, 155 p. NTIS number PB2015-103741. doi:10.7289/V5/TM-NWFSC-128.

127 **Roni, P., G.R. Pess, T.J. Beechie, and K.M. Hanson. 2014.** Fish-habitat relationships and the effectiveness of habit restoration. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-127, 154 p. NTIS number PB2014-108836.

126 **Russell, S., and M.S. Ruff. 2014.** The U.S. whale watching industry of Greater Puget Sound: A description and baseline analysis. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-126, 171 p. NTIS number PB2014-105939.

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