Response to ISRP on Project ID: 35003

Vitality based studies of Delayed Mortality
Sponsor: UW

Short Project Description: Based on the vitality survival model we will develop and deploy a field procedure to evaluate the contributions of freshwater events on delayed and extra mortality.

Short Response to ISRP Questions : The project has been significantly integrated with other delayed mortality projects resulting in immediate evaluation of the theory.

ISRP Preliminary Comments:
Generally fundable, but a response is needed. The project is designed to characterize the factors contributing to delayed and extra mortality. The technical background is addressed well with references and links to other work. The problem of identifying and solving delayed and extra mortality problems is complex due a variety of mechanisms through which mortality may operate. The proposed research is designed to study these mechanisms through theory, laboratory studies and field studies. The study could be valuable in helping to resolve these complex issues.

Response to IRSP issues
ISRP question 1*. Is it possible to evaluate this theory with existing or anticipated data from the CSS? That is, can the model be validated based on existing data?*

Yes, the theory can be evaluated with existing data.

To evaluate the hypothesis that that the ***ratio of average survival times in a survival challenge equals the ratio of SARs*** we will use data from the ongoing NMFS project "*A study to compare long-term survival and disease susceptibility of yearling hatchery chinook salmon smolts with different juvenile migration histories* (Gilbeath, Strom and Arkoosh)." In this study fish tagged from Rapid River Hatchery in Snake River Basin are collected at Bonneville Dam via arrival in barges and in-river passage routes. NMFS then takes these fish into holding facilities for disease challenge studies. The survival curves from these studies are made available to us for estimation of the vitality parameters. We currently have survival curves and have estimated vitality parameters from the first year of the study in 2001. The experiment will continue for several more years and will provide a number of survival curves representing a variety of different hydrosystem passage conditions. For an evaluation of the theory we also need SARs representative of the fish collected in the Disease Challenge experiment. This information is available from PITAGIS. In particular, we will estimate SARs from Rapid River Hatchery fish, marked as part of the CSS. Comparing the ratios of the vitality parameter against the ratios of the corresponding SARs constitutes an evaluation of the theory. Initial results will be available in 2003, with partial PIT tag returns from the 2001 challenge tests. Since the Disease Challenge tests and the CSS are ongoing projects, an ongoing evaluation of the vitality theory is feasible and efficient.

ISRP question 2*. Would it be possible to revise the proposal to incorporate data from Project #35047 that includes fish released at Lower Granite? This collaboration would allow this project to compare the survival and SARs for the two groups: those released at Lower Granite and those released at McNary?*

Yes, through discussions with G. Matthews at NMFS we have planned collaboration with Project #35047. Besides providing data to evaluate the vitality theory, our effort will strengthen Project #35047. The description is below.

The objective of Project #35047 is to use empirical experiments to quantify delayed effects associated with hydrosystem passage. NMFS will collect and tag fish at LGR dam, place them in trucks and then release them into Lower Granite Dam and Ice Harbor Dam tailraces. The null hypothesis, there is no extra mortality in dam passage, requires that the SARs of fish released in LGR tailrace are statistically indistinguishable from the SARs of fish released in IHR tailrace. However, the ISRP identified a hidden assumption in the NMFS experiment that could invalidate any conclusions from the study. Specifically, the experiment contains the assumption that the effect due to transport is the same for fish experiencing dam passage plus transport stress as it is for fish experiencing only transport stress. The NMFS response is that trucking stress is minimal. In our collaboration with the NMF experiment we will evaluate our theory and provide a quantitative test of the importance of the assumption identified by the ISRP. The outline of our work, developed in collaboration with NMFS, follows.

NMFS will allocate to our study 2% of the fish tagged for Project #35047 (~ 4000 fish): 1450 fish will be released with the LGR group (Scenario 1) and 1100 released with the IHR group (Scenario 2). In addition, 1450 PIT tagged fish will be released at LGR without trucking (Scenario 3). At John Day Dam we will collect 230 from each group using the sort-by-code PIT tag facilities at the dam. The fish will be placed in a single test challenge tank and stressed with elevated temperature using an experimental procedure prototyped at the UW Hatchery this spring. We will record the time to survival for each PIT tagged fish and from this data we will determine the mean survival time and vitality parameters according to passage scenario and collection time.

We will test the hypothesis addressed in ISRP Question 1 by comparing the ratio of our challenge experiment results for the Scenario 1 and 2 release groups against the ratios of SARs reported by NMFS for the same Scenarios.

To test the ISRP concernthat trucking stress will render the results invalid, we recast the NMFS experiments in terms of vitality theory as follows. The theory assumes that every freshwater event alters the rate of loss of vitality, which in turn affects the challenge experiment survivals and in the SARs. Table 1 identifies the stress events that fish experience in the Snake River under four passage scenarios representing current conditions: the LGR and IHR release groups in the NMFS experiment, current passage conditions, and reservoir drawdown. For any two scenarios i and j, the rates of vitality loss leading up to a challenge experiment at John Day Dam are r_i and r_j and the hypothesized relationship to adult survivals is $r_i/r_j \sim SAR_j/SAR_i$ where the SAR is measured from smolt passage at McNary Dam to adult return to Bonneville Dam. Note that our project will determine the vitality loss rates with the challenge experiments and the NMFS project will determine the SARs. The vitality parameter estimates are developed according to "A Parameter Estimation Routine for the Vitality-Based Survival Model" (Salinger Anderson and Hamel, in press Ecological Modeling) where errors are estimated with Goodness-of-fit measure (via a Pearson's C test).

In terms of the vitality theory NMFS's null hypothesis is $r_1 = r_2$: that is the stress in Snake River passage is the same for fish traveling through four dams plus a truck (Scenario 1) as for fish traveling through one dam plus a truck (Scenario 2). Then by inference, the stress in passing the four Snake River dams (Scenario 3) is equivalent to passing through the Snake River with no dams (Scenario 4) such that $r_3 = r_4$. From this, we would conclude no delayed extra mortality is associated with the Snake River dams. The ISRP's concern, that fish survive better in dam

passage than with dam passage plus trucking, requires $r_3 < r_1$. Furthermore, if trucking is highly stressful, then $r_3 << r_1$ and we would conclude that the difference in stress in passing one vs. four dams is swamped by the stress in trucking prior to dam passage in either case. In this situation, a null hypothesis, $r_1 \sim r_2$ is dominated by trucking stress and it is not possible to infer $r_3 = r_4$. Consequentially, the experiment would fail to resolve the issue of extra mortality. NMFS used circumstantial evidence, principally information on blood chemistry in trucked fish, to infer that trucking stress does not dominate dam passage stress. The survival challenge test will add a direct evaluation of trucking stress by comparing the challenge survivals from Scenarios 1 and 3. If statistically $r_1 \sim r_3$, then truck stress is small compared to the other stresses and so any differences in challenge survivals from Scenarios 1 and 2, which are quantified by the difference in r_1 and r_2, should reflect the differences in the number of dams that fish pass in each Scenario. If the challenge test survival for Scenario 1 fish is equivalent to the challenge test survival for Scenario 3 fish, then we may conclude trucking stress is small compared to the stress in passing the projects. We will then have reasons to believe that any differences in challenge test survivals and SARs between Scenarios 1 and 2 reflect the contribution of Snake River dams on extra mortality.

Table 1. Stress events in the fish passing through the Snake River under four scenarios.

Scenario	Description	Stress events	Vitality rate
1	NMFS experiment LGR release	LGR-Truck-LGS-LMN-IHR	r_1
2	NMFS experiment IHR release	LGR-Truck	r_2
3	Present day in-river	LGR-LGS-LMN-IHR	r_3
4	Reservoir drawdown	Snake River	r_4

Action Agency/NMFS RME Group Comments:
OCEAN AND ESTUARY SUBGROUP – The following ongoing projects are, or would, contribute to the delayed and extra mortality issues. Before funding this proposal a complete integration should be made with the COE's work, Carl Schreck, OSU, and with the ongoing NMFS and Dept. of Fisheries Oceans Canada project 1998-014 (now a separate proposal 30010), and the acoustic projects proposed in this RM&E section as 35046 and 35047, and the estuary as 30007.

The RME group requires complete integration of our delayed mortality proposal with other delayed mortality project. Complete integration is not practical at this time since the projects mentioned by the RME Group must focus on their objectives and cannot adapt to the needs or our study. However, some project can be integrated very effectively as is outlined above in response to ISRP questions 1 and 2. Overall, we have substantially increased integration regionally and can begin field testing the vitality theory using information from ongoing studies. Furthermore, some data from these studies will be incorporated in the Masters Thesis work of Molly Cobleigh and published within a year. And since the projects of opportunity are ongoing, we will continue the evaluation of the vitality theory in a very cost effective manner.

We believe that the vitality theory and challenge experiments will be of great value to other delayed mortality studies underway or proposed in the region. In particular, eventual integration of our work with the studies focusing on the estuary and ocean is feasible (Table 2). We envision that routine challenge tests of fish at Bonneville Dam from barge and in-river passage routes should provide a measure to separate the effects of fish condition from environment conditions on delayed and extra mortality. However, before routine vitality testing is implemented the theory must be further evaluated and the challenge test protocol must be refined and standardized. Under the program modifications identified above, we will begin these tasks in

the first year of the project. In addition, we have helped Carl Schreck of Oregon State University and Paul Ocker of the Army Corps establish a delayed mortality working group, which will provide a conduit for integration of projects and for sharing of information. The minutes of the first meeting held on July 10 2002 are attached as Appendix A.

Table 2. Key project that can be integrated with the Vitality Study.

Project	Principal Investigators	Agency	Action for integration
Salt Water Rearing and Disease Challenge	Gilbreath, Masada, and Clemons	NMFS	Obtaining data to develop survival curves
A study to evaluate delayed (extra) mortality associated with passage of yearling chinook salmon smolts through Snake River Dams (#35047)	Matthews and Marsh	NMFS	Have coordinated conducted survival challenge test for study and received SAR data
Physiology as a Factor in Delayed and Extra Mortality	Congleton	Idaho Coop Fish & Wildlife	Participation in the Delayed Mortality workgroup
Lower River, Estuary and Plume Behavior	Schreck	OSU	Participation in the Delayed Mortality workgroup
Evaluation of the relationship among time of ocean entry, physical, and biological characteristics of the estuary and plume environment, and adult return rates	Muir and Emmett	NMFS	Integration proposed for second year of vitality project
A Study to Estimate Salmonid Survival Through the Columbia River Estuary Using Acoustic Tags	McComas, Ferguson, and Smith	NMFS	Integration proposed for second year of vitality project

Appendix A

Delayed Mortality
Physiology Workshop
July 10, 2002

Hosted By:
Oregon State University
317 SW 6th
Portland, Oregon

At the Delayed Mortality Workshop held at Skamania Lodge on February 19-20 of 2002, the meeting broke out into several groups to discuss many of the major components of Differential Delayed Mortality "D" and how these items might be addressed. The breakout group that was to discuss physiology, and how it might relate to "D", proposed to have an additional meeting to discuss the issue more thoroughly. Dr. Carl Schreck at Oregon State University hosted this informal meeting/workshop. Paul Ocker from the Corps of Engineers took notes.

The notes in attachment A were taken at the meeting in Skamania for the physiology workgroup.

Attending:

Noah Adams	USGS-Cook	(509) 538-2299	Noah_Adams@usgs.gov
Jim Anderson	Univ. of Washington	(206) 543-4772	Jim@CBR.washington.edu
Chris Bill	NMFS	(503) 230-5403	Christopher.Bill@noaa.gov
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Tracy Collier	NMFS	(206) 860-3312	Tracy.K.Collier@Noaa.gov
Alec Maule	USGS – Cook	(509) 538-2299	Alec_Maule@usgs.gov
Paul Ocker	NWW Corps	(509) 527-7295	Paul.A.Ocker@Usace.army.mil
Cliff Pereira	Oregon State	(541) 737-1984	pereira@stat.orst.edu
Nat Scholz	NMFS	(206) 860-3454	Nathaniel.Scholz@Noaa.gov
Carl Schreck	OCFWRU	(541) 737-1961	Carl.Schreck@oregonstate.edu
Mark Strom	NMFS	(206) 860-3377	Mark.Strom@Noaa.gov

Tracy Collier
- Bonneville Rearing study
- The recirculation system is considered to be an additional stressor for the fish
- Disease challenge leading to delayed mortality
- Expected mortality rates were what was expected
- Rapid river stock fish were the only fish tagged
- Looking at the immune competence angle

Nat Scholz
- Sensory physiology

- McNary Reservoir Toxicants could easily be examined but the small exposure time may not lend itself to looking at this
- Data exercises of the barges could be performed to determine if barged fish are compromised by the barge experience itself
- Conventional studies of auditory and visual systems could be done

Carl Schreck
- Some Chehalis River work – immuno-depression of migrant coho indicated that mill effluent may compromise survival and results in poor return rate.
- Tom Carlson and Art Popper did a study indicating that infrasound was quite damaging to the nerve hair cells of salmonids
- John Nestler did some sound measurements in the barge
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- Questioned if D is driven by barging per se or is rather not due to the barges but rather that poor quality fish get loaded into barges at times while better quality fish become run of river fish. Garbage in/garbage out concept may be applicable to barged versus run of river comparison. Our work this year doing performance testing shows considerable variability in quality of fish over the run and general fitness of barged fish collected from the barge at Bonneville correspond to the general impression of quality of the fish by the biologists passing Granite.

Jim Andersen
- Jim is putting a paper together regarding information on T-helper cells not becoming engaged until temperatures are at 10°C.
- This is directly related to the immunological response of migrating fish
- This may be timed in with developmental changes in the fish
- When looking at "D", looking at the composites of stocks is inappropriate
- We really need to get better collaboration among us
- Look at immune-suppression in colder water

Noah Adams
- With respect to Bill Muir's hypothesis, they are considering a proposal for a possible study regarding intentionally infected fish with BKD to determine the guidance of highly infected versus uninfected fish.
- Other possible studies may involve buoyancy effects

A question was raised regarding if we still consider hatchery fish to be a good surrogate for wild fish, which are the species of concern.
On a behavioral basis, Fall chinook travel deeper and they are harder to detect.
Monitoring scheme of Interdam/Barge and early vs. late migrating fish
** - Talking with Mike Halter at LGR Dam, it is possible to look at fish from individual barges
Is there a Density Issue?
Is there a temperature issue?
How would we quantify some of this information?
How can we try to coordinate all of the different research into one product?
Do we need to look at how fish are collected and held?
Mark Strom – Currently doing necropsy work on the rearing study fish
Is there a size issue?
** - Jim Congleton will be looking into the size selectivity of the hydroprojects.
Are tag codes recovered from bird islands being looked at by their date of passage at the various locations?
Other things that have been looked at include Videotaping, cortico-steroids, swimming performance, trucking and saltwater challenges

We could also correlate hatchery disease profiles
Correlate travel distance for culling
Correlate temperature
Look at the Barge itself—do the barges differ from each other
Do some looking at adult studies

What other Research might be valuable to perform to try to get a handle on "D".

Tracey Collier Barge Environment

- Fish performance measures after barging
- Disease Transmission in the holding and barging scenario
- Look at the compressed migration timeframe
- Look at the Mechanical Environment
- Loading and unloading issues

Fish Bypass Systems

- Collection and Bypass
- Look at unique attributes against fish physiology
- Look at the ecological Relevance
- Diseases

If we start with poor condition fish, where does that leave us.

Nate Scholz Defer

- Olfactory Questions
- Look into the Popper Research for nerve hair cell damage

Shaun Clemens Estuary Work

- Continue the PIT Tag Island recovery work
- Determine if birds are targeting sicker fish
- Look Into Large Ship passage and predation (based on observations of many birds preying on something after a large vessel passes in the ship channel)
- Performance Tests, energy Intake, Salt Water Entry
- Look at performance and fish startle difference
- Predator avoidance
- Look at Timing of release of fish

Noah Adams Overall Fish health

- We need to consider the Garbage In Garbage Out (GIGO) theory
- When fish of poor health are barged, do they survive differently than healthy fish?
- Is this a buoyancy/disease selectivity of these fish?
- Perhaps we need to do something along the line of what Bill Muir was proposing.

Carl Schreck Overall

- Continue with what we are currently doing

- Work on better fish sorting at the dams
- Develop a monitoring system for GIGO theory
- Supported Tracy's view, What is mechanistically happening in the barge
- Level of smoltification
- Can we do a test of barging every other day and bypassing every other day to look at in season variability?
- Is there a question of Basic Biology, are fish getting somewhere too early or too late?
- Gene Chip technology - can we look at different Genes turning on or off
- Develop Biosensors to diagnose the different groups of fish, couple this with more intensive monitoring
- Determine if releases from barges either further downstream or coinciding with tidal flow predicted to minimize time in the estuary (vulnerability to birds) could affect D.
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- BETTER COORDINATION AMONG GROUPS WORKING THE SAME ISSUE

Cliff Pereira <u>In General</u>

- Is there a better way to directly measure things
- We should find a way to either better fund or eliminate studies if they are not statistically valid

Jim Andersen <u>GIGO Theory</u>

- Look at the Barge itself
- Overlap with the PIT tag Program
- Take a more in depth look at the hatcheries upstream
- BETTER COORDINATION AMONG GROUPS WORKING THE SAME ISSUE
- Share fish and do common experiments on common groups of fish
- Look at fish condition and see where they go in the hydrosystem
- Look at What makes a fish a "bad fish"
- Are we putting good or bad fish into the ocean

Alec Maule <u>Fish Quality</u>

- Consider the Quality of fish that get barged with the quality of fish that do not
- It should be noted that the quality of fish that are released from the hatcheries should be looked at

DNA microarrays – (same as gene chip mentioned by Schreck). These are tools to tell us where to start looking . A microarray with known DNA sequences can tell us what physiological systems are being affected.

Mark Strom <u>Fish Quality</u>

- We should be sampling at different points in time
- Combine the quantitative of disease with the T-Helper cells
- We should try to determine what produces stress in fish and what causes "D"