NORTHWEST STRAITS
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NORTHWEST STRAITS COMMISSION

Improvements to the Coho Fishery Regulation Assessment Model (CohoFRAM)

FINAL REPORT
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Prepared for:
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Final Report

Improvements to the
Coho Fishery Regulation Assessment Model (CohoFRAM)

Prepared for the Tulalip Tribes By

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June 2011

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Coho Fishery Regulation Assessment Model (CohoFRAM)

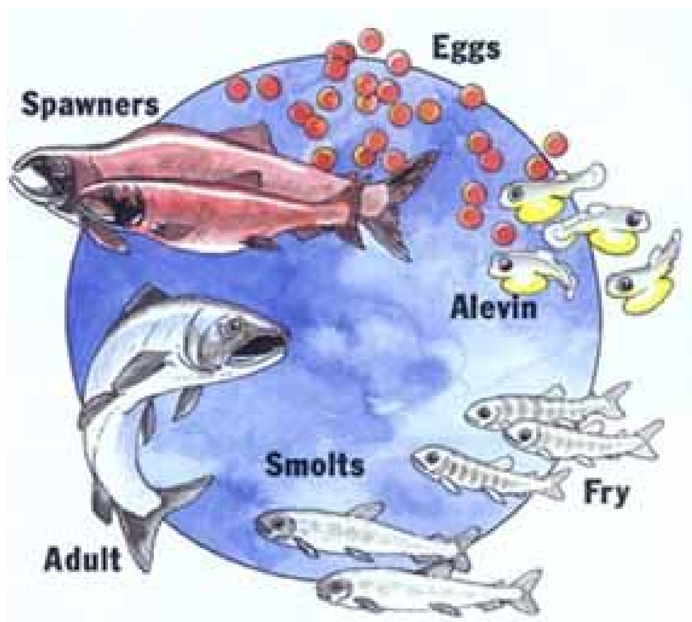
Project Purpose:

Explore the feasibility of developing a research consortium to identify environmental influences on the early marine survival and distribution of Chinook and coho salmon in the Salish Sea (Puget Sound to mouth of Juan de Fuca and Strait of Georgia to Johnstone Strait) and incorporating environmental data into annual management process that utilize FRAM. Attachment A.

Methods

The investigation involoved a literature review and interviews with a number of knowledgeable, respected scientists and administrators (Attachment B).

Background:



Basic biology. Coho salmon originating in Puget Sound and Southern British Columbia rivers spawn in small tributaries, rear for an extended period (~18 months) in freshwater, and spend 18 months at sea. Except for jack (early spawning 2-year old males) the species has a predominantly 3-year life cycle, with the vast majority of growth and harvest occurring during the last four months of life.[1]

The three year life cycle of coho has the following major implications for harvest management: (1) regulation of harvest to attain desired spawning escapement is limited to a single maturing age class; (2) marine survivals are believed to be dependent on environmental conditions when juvenile smolts enter salt water – consequently, co-variation of survivals from stocks originating from the same geographic area (e.g., Puget Sound or Strait of Georgia) is likely; and (3) coho from the same stream actually consist of three virtually separate populations that are genetically isolated (except for the influence of jacks).

Extended freshwater rearing and hatchery-wild interactions in estuaries makes coho particularly susceptible to local environmental and anthropogenic influences; however, iinteractions appear to be highly variable and complex. In the marine environment, stock and temporal variations in survival and growth have been observed during unusually intense marine environmental events such as El Niño and La Niña.

[1] Sandercock, F. K. 1991. Life History of Coho Salmon, "Oncorhynchus kisutch". Pages 397-445 in C. Groot and Margolis, editions. Pacific salmon life histories. University of British Colombia Press, Vancouver, British Colombia

Coho FRAM. The Coho Fishery Regulation Assessment Model (CoFRAM) is a coastwide fishery management planning tool for coho salmon and is currently used for bilateral regional fishery planning by the United States and Canada under the provisions of the Pacific Salmon Treaty. Various versions of CoFRAM have been employed since the mid 1970's to evaluate impacts of marine and freshwater troll, sport, and net fisheries on coho salmon stocks originating from California to Southeast Alaska using monthly time steps for both preseason planning and postseason assessment. Extensive documentation of the FRAM is available from the Pacific Fishery Management Council.[2]

At its core, CoFRAM accounts for mortalities on individual hatchery and wild, marked (with adipose fin clip) and unmarked components of individual stocks.[3] Most coho stocks along the eastern Pacific coast, including those originating in Puget Sound and Southern British Columbia rivers, have substantial hatchery production. CoFRAM relies upon coded wire tag (CWT) recovery data from release groups collected during a base period to characterize average stock distribution and exploitation patterns. CoFRAM base period are derived almost entirely from CWT recoveries of hatchery release groups which are believed to have the same marine distribution pattern as naturally-produced smolts from the same geographic area. Adult distribution patterns are assumed to be characterized by base period averages regardless of abundance forecasts.

Each season, the model is calibrated using preseason abundance forecasts for hatchery and natural stocks. Due to high interannual variability in survivals and local freshwater and marine environmental conditions, abundances are forecast using a wide assortment of methods, including sibling relations (jacks to adults), recent year survival rates for hatchery stocks, low summer flows, and environmental variables (e.g., sea surface temperatures, upwelling indices, overwinter flows)[4].

For preseason planning, proposed regulations for fisheries are evaluated using forward cohort projection methods to generate stock-specific estimates of fishery mortalities, escapements, and exploitation rates.

For post-season assessments, a backwards version of CoFRAM is employed to generate estimates of fishery exploitation rates on marked and unmarked components of individual stocks. Backwards CoFRAM employs an iterative process that estimates initial stock abundance from reported data on stock escapements and fishery mortalities. With the growing use of mark selective fishing for coho, direct estimates of fishing mortality on fish produced from natural spawning cannot be derived from CWT recovery data since much of that mortality is unobservable. Post-season estimates of stock abundance, combined with accounting of fishery and natural mortalities by CoFRAM enables estimates of observed exploitation rates to be produced.

For purposes of this investigation, the key assumption is underlying both pre-season and post-season use of CoFRAM is that the stock distribution patterns reflected by base period CWT recovery data provide an adequate representation of true stock distribution patterns.

The validity of this assumption came under question as a series of strong El Niño and La Niña

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[2] FRAM documentation (overview, technical description, base period development, programmer's guide, user's manual) can be downloaded from: http://www.pcouncil.org/salmon/background/document-library/fishery-regulation-assessment-model-fram-documentation/

[3] Unmarked and unmarked components are modeled because of the extensive use of mark selective fishing regulations which allow marked hatchery fish to be retained at higher rates than unmarked fish. Since not all fish die after release, mark selective fishing is intended to increase access to hatchery-produced fish within fishery exploitation rate constraints established for natural (unmarked) stocks.

[4] E.g., Wang, S., G. Morishima, R. Sharma, and L. Gilbertson. 2009. The Use of Generalized Additive Models for Forecasting the Abundance of Queets River Coho Salmon. North American Journal of Fisheries Management 29:423–433.

events were experienced which appeared to result in abnormal survival and CWT recovery patterns beginning in the early 1980's. Of particular concern was the substantial deviation from distribution patterns during the base period for coho stocks originating in Puget Sound and Strait of Georgia (collectively referred to as the Salish Sea) deviated. Most noticeably, these "inside" stocks were found almost exclusively outside Vancouver Island until maturation, instead of residing in the Strait of Georgia. These deviations from base period assumptions raised concerns for the accuracy and reliability of predictions of mortalities under proposed and adopted fishery regulations. Some research was conducted in an attempt to determine causal factors, but results have not been definitive.

In 2009, the Pacific Salmon Commission's (PSC) Coho Technical Committee (CoTC) undertook a project to recode CoFRAM and its various support programs used to develop input data sets into Microsoft Visual Basic.NET system. This opportunity prompted interest by the PSC Southern Panel in exploring the feasibility of using different base period data sets depending on environmental cues. Specifically, there was interest in determining if the Hydrodynamic Model of Puget Sound and Northwest Straits being developed by the Pacific Northwest National Laboratory (PNWNL Model) to project potential impacts of climate change on salmon populations in Puget Sound could provide information that could predict ocean survival and distribution patterns to help select base period data sets for CoFRAM. The project was funded by the Northwest Straits Commission through the Tulalip Tribes.

Findings:

Pacific Northwest National Laboratory Hydrodynamic Model

Researchers developing the PNWNL Model were interviewed and published literature describing the model was reviewed[5]. The PNWNL Model is a 3-dimensional particulate flow model that attempts to tie spatial-temporal behavior of juvenile salmon to physical parameters such as flows and temperatures. The can generate a huge amount of data ("pixel size" is 10 m^2 for river areas and up to 400 m^2 for estuarine and marine areas for 14-day periods). In the PNWNL Model, fish are considered just another type of particle. The model is being used to explore relationships between habitat conditions and use of juvenile Chinook salmon in freshwater areas and in estuarine areas of Puget Sound. The PNWNL model is very data intensive, but is capable of being modularized and expanded to cover the Strait of Georgia as well as Puget Sound.

The model is currently being calibrated to Skagit fall Chinook, and attempts to relate distribution of fish at various life history stages to physical characteristics in particular habitat types. The PNWNL Model is based on 4 years of data recording the abundance of smolts in particular types of habitat in the river and estuary. The motivation for developing the PNWNL Model lies principally in predicting impacts of climate change, watershed & estuarine restoration and mitigation efforts on salmon productivity.

The most promising area for using the PNWNL Model to inform FRAM lies in the prediction of survival and abundance from data describing environmental conditions. However, the PNWL Model is currently focused on juvenile/early marine life history stages of fall Chinook. The PNWL Model is neither constructed nor parameterized for coho salmon so it lacks the capacity to make inferences for coho survival or adult distribution patterns have not yet been explored. Chinook and coho would not be

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[5] Yang, Z and T. Khangaonka. 2007. Development of a Hydrodynamic Model of Puget Sound and Northwest Straits . Prepared for the NW Straits Commission, Mt. Vernon, WA. 74p. Greene, C.M., D.W. Jensen, G.R. Pess, E.A. Steel, E. Beamer. 2005. Effects of Environmental Conditions during Stream, Estuary, and Ocean Residency on Chinook Salmon Return Ratesin the Skagit River, Washington. *Transactions of the American Fisheries Society* 134:1562–1581, 2005

expected to respond similarly to environmental factors because of differences in size and life history patterns. No efforts are currently underway to try to parameterize the PNWNL Model for coho.

Other relevant research

A literature search found few studies of predictive relationships between survival and distribution patterns and environmental influences of coho salmon. Lawson et.al.[6] examined historical relationships between seasonal stream flows and air temperature on freshwater survival and production of Oregon coastal and Queets (Washington coastal) natural coho salmon. Coronado and Hilborn[7] found north-south and inside-outside differences in marine survivals using El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) events and surrogates for marine environmental conditions. Productivity of coho stocks in the inland waters of the Salish Sea is believed to be primarily a result of some combination of tidally-driven vertical mixing, river flow, and nutrient-rich water from coastal areas and does not appear to be clearly tied to cold or warm ocean regimes; further impacts of ENSO and PDO events was highly variable. Weitkamp[8] examined recoveries of CWT experiments and theorized that recovery patterns hinted at the existence of environmental "hotspots" that "may serve as important reservoirs for the continued existence of populations that are particularly vulnerable to climate change due to their restricted marine distributions." However, no published research was encountered which provides evidence of reliable predictive relationships between environmental conditions and survival and adult distribution patterns of coho salmon stocks originating in rivers entering the Salish Sea.

Much of the research into early marine life histories of Puget Sound and Strait of Georgia coho s is still in process and has not been formally published. A few research studies have reported relationships between ocean conditions and early marine survival of coho salmon,[9] but little information on environmental determinants of ocean distribution patterns of adults was encountered through a literature search.

Some sparse data for coho salmon juveniles from sampling surveys in the Strait of Georgia relating to genetic stock identification and physical condition of juveniles suggest stock-specific grouping and survival over relatively short time frames.[10] Tracking of a small number of juveniles containing individually coded acoustic archival tags using POST

[6] Lawson, P.W. , E.A. Logerwell, N.J. Mantua, R.C. Francis, and V.N. Agostini. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquat. Sci. 61: 360–373.

[7] Coronado, C., and R. Hilborn. 1998. Spatial and temporal factors affecting survival in coho salmon (*Oncorhynchus kisutch*) in the Pacific Northwest. Can. J. Fish. Aquat. Sci. 55:2067-2077. See also Ocean Ecosystem Indicators of Salmon Marine Survival in the Northern California Current. NOAA Fisheries Service, Northwest Fisehries Science Center http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/a-ecinhome.cfm

[8] Laurie Weitkamp(2008). Marine Sistributions of Coho and Chinook Salmon Inferred from Coded Wire Tag Recoveries. Proceedings of the International Fish Tagging Workshop on "Advances in Tagging and Marking Technologies for Fisheries Management and Research," 24-28 February 2008, Auckland, New Zealand.

[9] Ryding, K.E. and J.R. Skalski. 1999. Multivariate regression relationships between ocean conditions and early marine survival of coho salmon. Can J. Fish. Aquat. Sci. 56:2374-2384; Wang, S. G. Morishima, R. Sharma, and L. Gilbertson. 2009. The Use of Generalized Additive Models for Forecasting the Abundance of Queets River Coho Salmon. North American Journal of Fisheries Management 29:423–433; Lawson, P.W., E.A. Logerwell, N.J. Mantua, R.C. Francis, and V.N. Agostini. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquat. Sci. 61: 360–373

[10] Dick Beamish, pers. com.

arrays has provided some intriguing hints of early marine mortality and migration patterns.

A November 2009 proposal prepared by the Pacific Salmon Foundation describes a research study to investigate the causes for declines in Chinook and coho abundance in the Strait of Georgia and identify the primary mechanisms controlling production in order to develop a restoration plan for these species.[11]

Patterns of survivals of Chinook and coho salmon entering the Salish Sea have diverged in recent years. Fish entering the Strait of Georgia have experienced prolonged periods of depressed survivals relative to those entering Puget Sound. The reasons are not clearly understood, but researchers have conjectured about the potential impact of recent changes that have been observed in environmental conditions, such as water temperatures being 2 degrees Celsius cooler in Puget Sound than the Strait of Georgia, conditions of kelp and eel grass beds, salinity, and differences in wind direction and velocity. Much of the information on early marine survival of coho entering the Salish Sea has been collected incidentally during studies directed at other species or is based on inferences or extrapolations outside the original purpose and intent of the effort that collected the data.

A great deal of research is being conducted in Puget Sound, the Strait of Georgia, and off the coast of Washington and British Columbia to try to gain insight into causal factors affecting early marine survival of Chinook, coho, and especially sockeye salmon. However, relatively little of this research is aimed at improved understanding of early life histories of coho; the vast majority of effort is is directed at Chinook (Puget Sound) and sockeye (Strait of Georgia/Fraser River) due to conservation concerns for these species.

It is clear that these efforts are being undertaken largely in isolation. Research into causal factors affecting early marine survival of Pacific salmon originating in rivers flowing into the Salish Sea is largely being undertaken independently, with little collaboration between and among researchers or funding agencies. Research results are shared principally through publication or occasional presentations at professional conference. Funding priorities are aligned with agency missions or directed at local issues affecting individual stocks or watersheds.

Conclusions and Recommendations

Two basic paths can be pursued to develop the capacity to incorporate environmental conditions into processes that rely upon CoFRAM: (1) a mega research project and the institutional capacity to conduct it could be prepared and efforts undertaken to obtain necessary funding support; or (2) a mechanism could be developed to improve collaboration of research on smaller-scale projects to address major knowledge gaps.

Given the current state and primary focus of the PNWL Model on Chinook, it is not feasible to try to integrate the PNWNL Model into Coho FRAM-based preseason or post season planning processes. Substantial amounts of funding would be required over several years to conduct the research necessary to develop a hydrodynamic model for coho, validate predictive capabilities, and incorporate results into fishery management processes that rely upon Coho FRAM, both technically and administratively. Such an effort would involve: (a) conducting the research necessary to reparameterize the PNWNL Model to represent coho instead of fall chinook; (b) expanding the geographic scope of coverage beyond central Puget Sound and collation of data necessary to characterize species-habitat utilization and dependencies; (c) establishing monitoring and reporting programs to collect and provide relevant environmental data in a time

[11] Riddell, B., I Pearsall, and Science Panel. Strait of Georgia Chinook and Coho Proposal. November 17, 2009.

frame required for use in CoFRAM annual planning cycles; (d) collation of relevant data on coho distribution patterns for both juvenile and adult life cycle stages; and (e) analysis/synthesis to identify and test causal relationships and predictive reliability. In short, substantial research would be required to identify predictive relationships between environmental conditions and early marine survival and marine distributions of coho salmon entering the Salish Sea. A large-scale, multi-year project would need to be developed and funding secured for implementation. Besides the practical difficulty of obtaining stable, long-term funding to support an endeavor of such magnitude and complexity, substantial knowledge gaps exist and the scientific knowledge and institutional capacity to provide consistent guidance and direction does not presently exist.

While it appears that it would be possible to devise a collaborative research proposal involving the PSC Coho Technical Committee, the PNWNL, and NOAA fisheries, given the climate of governmental fiscal austerity, prospects for securing financial support are at best highly uncertain, with the possible exception of resources to investigate potential impacts of climate change on salmon.

The second path, to substantially improve coordination and collaboration of research activity, is recommended. A means to improve multi-agency coordination and collaboration of research investigating factors that influence early marine survivals of salmon is sorely needed. Although the focus of this investigation is on coho, there appears to be substantial interest in considering other species, such as Chinook and steelhead (because of listing under the Endangered Species Act), pink and chum (because of observed interactions with Chinook), and sockeye and pink (because of current controversies over recent declines in abundance of stocks of these species produced in the Fraser River).

Development of a research consortium may be a viable means to improve coordination of multi-agency research. Under such a consortium, researchers would (a) participate in a workshop to collaboratively develop a research strategy, identifying major questions to be addressed and recommendations for investigative approaches; (b) conduct research independently (e.g., hydrodynamic modeling, genetic stock identification, POST, coded-wire-tag experiments and analysis); and (c) share, review, and collectively synthesize research results through an intensive workshop. This process would be undertaken iteratively.

This type of approach is not a novel concept. Several processes have been developed in attempts to improve collaborative research. For example, the US Fish & Wildlife Service has established a Recovery Monitoring and Evaluation Group for Bull Trout; the Pacific Salmon Commission recently convened a workshoip focused on concerns for productivity of Fraser Sockeye[12], and a formal process was employed to investigate alternative hypotheses regarding simultaneous changes involving habitat, harvest, hatchery, hydropower operations, and ocean conditions.[13]

The ability to improve collaboration among researchers will need to contend with piecemeal domains of topical and site-specific investigation and funding. An enduring framework is needed to establish and iteratively identify research priorities and collectively evaluate research results.

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12 Peterman R.M., D. Marmorek, B. Beckman, M. Bradford, N. Mantua, B.E. Riddell, M. Scheuerell, M. Staley, K. Wieckowski, J.R. Winton, C.C. Wood. 2010. Synthesis of evidence from a workshop on the decline of Fraser River sockeye. June 15-17, 2010. A Report to the Pacific Salmon Commission, Vancouver, B.C. Available via the internet: http://www.psc.org/pubs/FraserSockeyeDeclineWorkshopIntro.pdf.

13 Plan for Analyzing and Testing Hypotheses (PATH). Marmorek, D. and C. Peters. 2001. Finding a PATH toward scientific collaboration: insights from the Columbia River Basin. Conservation. Ecology **5**(2): 8. [online] URL: http://www.consecol.org/vol5/iss2/art8/

A conceptual outline of a proposal for establishing a framework for research collaboration and discussed through interviews (see Appendix B). Individuals who organized and participated in the June 2010 workshop on Fraser salmon were highly supportive of the processes and procedures employed. Several of those features are incorporated into the outline for a collaborative research consortium described below.

1. Statement of Purpose and Need (factors influencing early marine survival and distribution of Chinook and coho salmon entering the Salish Sea)
2. Charter (purpose, membership, product/outcome descriptions, time frame, contributions, etc.)
3. Proposed groundrules for sharing data/information to protect interests of researchers
4. Synthesis of available data and information (Role for PSC Coho and Chinook Technical Committees?)
5. Distribute materials well in advance to provide adequate time for review
6. Convene selected group (manageable size) to review the information, identify hypotheses and prepare specific seminal questions
7. Identify individuals to make presentations on information to support/refute hypotheses (allow sufficient time for Q&A and exchange of views to create opportunity to develop insights from synergy and sharing)
8. Assign individuals to formally review presentations and present findings and recommendations (similar to peer review)
9. Group discussion and deliberation to identify conclusions on state of knowledge and identify knowledge gaps
10. Selected neutral group to synthesize results and develop recommendations for research and monitoring programs
11. Review of report
12. Finalization of report & distribution to researchers and funders
13. Research undertaken. Results shared.
14. Repeat steps (4)-(13)

All individuals contacted during this study were supportive of developing a way to improve coordination and collaboration among researchers and indicated a readiness to participate. While few extensive comments were received, feedback from interviews was positive and supportive. The observations shared by Steven Pennoyer, the most extensive received, are reproduced below:

> *"I am very glad that you are undertaking the idea of making research studies and their PIs more of an interactive function than now exists. I am certain that in your extensive experience none of my observations will be new or startling to you. Nevertheless, for what it is worth here is what I have seen over a life as a fisheries researcher, manager, and administrator for a state, the Feds and as a contractor. Additionally during this time I have been very lucky to have seen how the system works (or doesn't) in both freshwater and marine ecosystems and nationally and internationally, mostly for salmon but also shellfish and groundfish. While*

working for the Feds I also had an opportunity to see how things were done in the other regions and headquarters within NMFS.

The main problem seems to be the concept of management and what it means within the agencies and governments I have observed. It has varied from the narrow to a broader concept by time within most I have seen. This may be a topic outside your present idea, but may be basic to the effectiveness of any system. I have a recent and familiar story to illustrate-New England groundfish. Shortly-about three or four years-into my Federal life these resources crashed. I knew the Regional Director-the manager-fairly well and I spent some time talking to the Center researchers at Woods Hole as well. I am not sure anyone could have prevented the declines for some species, but realistic planning may have spread the effects over a longer period and ameliorated the socio-economic and biological impacts.

Unfortunately, while the Center scientists forecasted the stock declines and were able to later say that they had been right, no one actually came up with a mechanism to turn this around that was doable, enforceable and saleable. So until the agency found itself in the midst of a lawsuit and belatedly adopted hard quotas, nothing much was really changed. A lot of small boats, family traditions a lack of understanding by the managers and headquarters and essentially a poor system of communication-interaction-between all the elements involved practically guaranteed that our best foot would not be put forward. Sorry to say that this has not been a solitary situation. Management should be an overarching concept that includes research, implementation, enforcement, and prosecution. Many agencies are doing more of this interaction now, but it is far from perfect. The "manager" is not the relatively uneducated politician sometimes envisioned, but must be able to both use and evaluate input from many areas, communicate with our public and implement in or preseason the appropriate regulatory strategies to achieve some type of extended term optimal yield or at least to try to reach this nirvana.

All well and good but probably more than you are interested in butting up against for now. In the area of fisheries research this isolation phenomena is also often evident as well. In far too many recent situations this has been a major stumbling block for achieving useable results. I am sure you have seen this in the PSC in our dealings with the Fraser late run sockeye, the CWT and genetics issues. At several workshops on these topics we saw that the PIs had not actively discussed their findings and problems with each other and lost out on both logistical and analytical opportunities. I recall vividly on workshop when a scientist I like and admire admit that he had never heard what the issue was for the stocks we were working on or what the scope and findings were for other studies. Perhaps his work was to be built in to an overall model by someone else, but I still think that the exact line between his work and the next study on the list (spatially and temporally) was rather blurred and everything from money for his studies, timing and content were rather obviously related to the overall stock needs. Not *everyone has access to all the brainpower they need and the appropriate person may be across the hall or in another group or agency entirely. There are lots of reasons to collaborate. Nationalism is fine and a pride in work and that of your groups work may be ok, but in this day of increasing costs and complexity we can ill afford to allow artificial barriers between scientists and managers to stand in the way of basing our decisions on good information. Within this fabric there should be plenty of room to deal separately with differences on allocation and national or sector allocation.*

Maybe one thing that would help more would be doing a better job of communication. Too often we simply do not understand what the expert is trying to tell us in a given field. Maybe a translator with the ability to talk to the decision makers is needed. Sounds like I am arguing for an in between position that understand the need and the statement but not only from a single viewpoint. Maybe some are already doing this, but not enough exist."

Project Funding

Funding support for this study was provided by the Northwest Straits Commission through the Tulalip Tribes.

Attachment A

Background: Under the Pacific Salmon Treaty agreement for abundance-based management of Coho Salmon in the boundary area between British Columbia and Washington State, bilateral agreement to employ the the Fisheries Regulatory Assessment Model (FRAM) for planning and post-season assessments of coho fisheries in the Pacific Salmon Commission's Southern Panel area.

FRAM has been used for planning Chinook and coho salmon fisheries in United States waters south of British Columbia for several years. It generates estimates of harvest, escapement, and exploitation rates assuming average stock distribution patterns during a selected base period. However, annual variability in survival and distribution patterns from these base period averages can lead to erroneous conclusions regarding fishery impacts on individual stocks. Environmental conditions affecting Chinook and coho are undergoing change from development and habitat restoration and long term effects of climate change on water, wind, and temperature patterns affecting Chinook and coho salmon are uncertain.

The Coho Technical Committee of the Pacific Salmon Commission (PSC) is in the process of converting the computer code from an un-supported version of Microsoft Visual Basic into Visual Basic NET. As part of the recoding effort, this project will assess the feasibility of developing a research consortium to identify environmental influences on the early marine survival and distribution of Chinook and coho salmon in the Salish Sea and incorporating environmental data into annual management process that utilize FRAM. If feasible and future work to incorporate environmental data is successful, errors in fishery planning and management of Chinook and coho salmon could be substantially reduced.

Task Description: MORI-ko will collaborate with the Pacific Salmon Commission's Technical Committees, the Pacific Northwest National Laboratory, NOAA Fisheries, and other entities to conduct a feasibility assessment of incorporating environmental data into to better predict the distributions of fish stocks and thus improve FRAM.

Attachment B

CDFO Pacific Biological Station (Dick Beamish, Wilf Luedke, and Mark Saunders)

ESSA (Dave Marmorek)

NOAA Fisheries, Alaska (Steven Pennoyer)

NOAA Fisheries, Montlake Laboratory (Correigh Greene and Kurt Fresh)

NOAA Fisheries, Olympia Field Office (Larry Rutter)

Northwest Indian Fisheries Commission (Gary Graves)

Pacific Northwest National Laboratory (Tarang Khangaonkar)

Pacific Ocean Shelf Tracking Project (Jim Boyer, Gerry Kristianson, Jonathan Thar)

Pacific Salmon Commission (Mike LaPointe)

Pacific Salmon Foundation (Brian Riddell)

Skagit System Cooperative (Bob Hayman and Eric Beamer)

University of British Columbia (Carl Walters)

University of Washington School of Fisheries (Ray Hilborn)

Washington Department of Fish & Wildlife (James B. Scott)