PROJECT CROOS

Collaborative Research on Oregon Ocean Salmon

Final Report

Project Funded by the Oregon Watershed Enhancement Board
To the Oregon Salmon Commission

March 2007

OREGON TROLL SALMON
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Using "Real Time" Genetic Information to Address the Klamath 'Weak' Stock Crisis for Oregon's Ocean Salmon Fishery

EXECUTIVE SUMMARY

Background

A major objective in salmon fishery management is ensuring access to healthy populations while also protecting weak stocks. Given limited understanding of the behavior and migration patterns of individual salmon stocks, it is difficult to manage stocks as distinct units. Ocean salmon managers are often compelled to institute large time/area closures to protect the weakest stocks. In 2006 this problem became acute when managers were forced to close most of Oregon and California's ocean troll salmon fishery to protect weak runs of Klamath River Chinook salmon. The result was the loss of 100's of jobs and millions of dollars in coastal income and a declaration of a "salmon disaster" by the Governors of California and Oregon.

To address the challenge of inadequate science supporting management of multi-stock ocean salmon fisheries, the Oregon Salmon Commission, together with scientists from Oregon State University and federal and state agencies co-located at the Hatfield Marine Science Center, formed the CROOS group (*Collaborative Research on Oregon Ocean Salmon*). CROOS proposed a comprehensive pilot project to test the potential of using *genetic stock composition* (GSI) and the GAPS database (Genetic Analysis of Pacific Salmonids) to identify in "real time" spatial and temporal characteristics of individual salmon stocks. It was proposed that the availability of "real time" data could potentially enable fisheries managers to 1) differentiate stocks in "real time" at refined spatial areas, 2) improve salmon conservation while allowing harvest of healthy stocks, and 3) integrate science and management of freshwater, estuarine, and marine salmon ecosystems. In June 2006, the Oregon Watershed Enhancement Board (OWEB), as part of a state-wide effort to provide salmon disaster assistance, agreed to fund a CROOS pilot project to test the potential application of GSI techniques.

Objectives

The goal of *Project CROOS* was to conduct collaborative and interdisciplinary research and develop protocols using GSI science in near "real time" that could 1) improve science, management, and marketing of West Coast salmon, 2) minimize harvest of "weak stocks," and 3) enhance economic value of the ocean salmon fishery. Specific objectives included 1) providing financial assistance to participating salmon fishermen, 2) developing sampling protocols for fishermen and fleet coordinators/managers, 3) conducting near "real time" GSI analysis, 4) developing digital technologies and "traceability" systems, 5) designing a comprehensive web site, 6) developing methods for collecting oceanographic information, and 7) considering potential of GSI technologies for improving salmon management.

Findings and Results

Financial Assistance The project provided financial assistance to 20% of the active Oregon fleet. More than 72 vessels participated in at least one opener (72 operators, 54 crew). Over 4,270 fish were sampled which represented 17% of the Oregon commercial salmon harvest in 2006. A total of $332,100 was distributed to operators and crew.

Protocols Project managers developed detailed protocols for biological sampling, data collection, fleet management, fishermen training, and project coordination.

Genetic Stock Identification (GSI) Over 4,200 tissue samples were delivered to the Coastal Oregon Marine Experiment Station (COMES) genetics laboratory along with associated digital or manual data. A total of 3,097 samples were processed and 2,567 fish were used to estimate stock mixture proportions. Probability values of stock assignment for these fish ranged from 28% - 100%. A total of 2,097 fish were assigned probabilities $\geq$ 90% to a specific hatchery or reporting region.

Stock Mixture Proportions The majority of sampled fish originated from California's Central Valley (59.08%). The Rogue River contributed the second greatest proportion (7.61%), followed by the Mid Oregon Coast (7.11%) and the Klamath basin (6.58%). The California Coast and Northern California/Southern Oregon Coast regions contributed 2.17% and 1.89% respectively. The Upper Columbia River summer/fall run was estimated to contribute 3.03% of the total. Twenty other stocks contributed less than 2% each.

100% Assignment of Coded Wire Tagged (CWT) Fish Thirty-one of the 2,097 fish that met the 90% probability criteria contained coded wire tags. All 31 CWT fish assigned to the correct hatchery of origin.

Near "Real Time" Analysis Near "real time" genetic analysis (within 24 - 48 hours after the fish were landed) was difficult to achieve during the initial few months of the project due to logistical issues and inadequate investment in laboratory resources. However, by September/October, fish were successfully assigned to individual genetic stock estimates in near "real time" and accompanying data entered into the database.

Geographic Information Systems (GIS) Maps GIS-based maps were developed that included troll tracks, precise time/location data on harvested fish, and menus for exploring relational data.

Dataloggers Digital datalogging devices for fishing vessels were successfully tested and proved to be easier to use than "manual" sampling protocols.

Website Development A working "prototype" website was developed capable of reporting information to multiple audiences using a variety of tools, maps and statistical analysis. The entire working website will be accessible by mid-late May 2007 at www.ProjectCROOS.com .

Oceanographic Data Collection by Autonomous Vessels A successful pilot test was conducted which showed that autonomous underwater gliders could be used in conjunction with commercial fishing vessels for collecting a wide range of oceanographic data.

Recommendations and Next Steps

Improving Project Protocols Many protocols will need adjustment in response to changing fishing and sampling conditions. CROOS project members can work with other West coast states, industries, and agencies to design, implement, and refine protocols.

Improving the GAPS Database The GAPS database requires continual improvement. Further characterization of stocks within and adjacent to the Klamath basin are recommended.

Expanding GSI Data Collection Coast Wide Implementing GSI for salmon management will require expanded data collection along the West Coast. Expanded data should be used to identify stock distribution patterns, test relevant hypotheses, and integrate oceanographic information.

Collecting and Integrating Oceanographic Information Oceanographic data will be critical for understanding salmon behavior and improving science and management. Future projects should combine vessel-based data collection with autonomous underwater gliders.

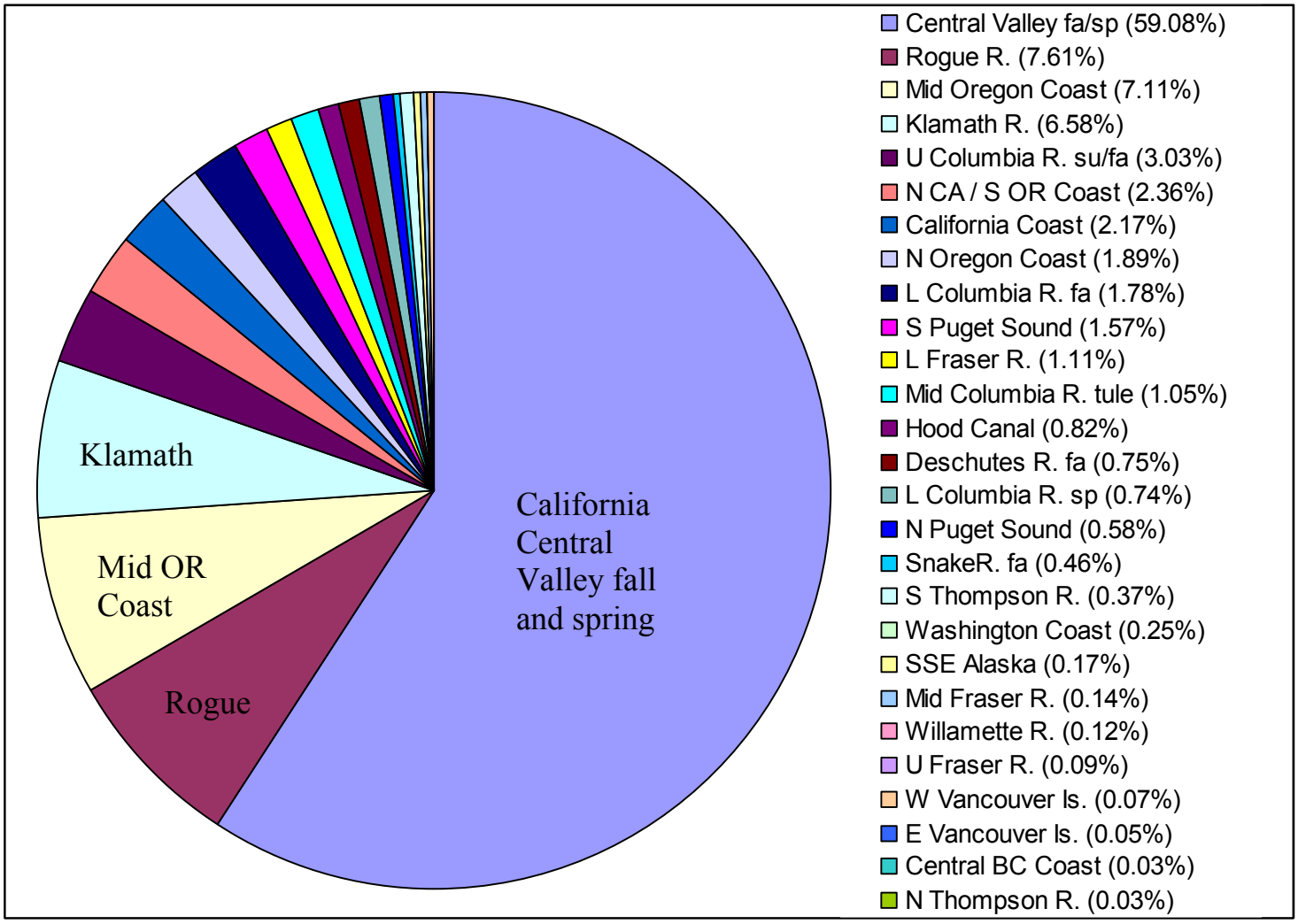
Improving the Design of Vessel Dataloggers Commercial digital dataloggers are inadequate given the needs for a tough, waterproof, relatively inexpensive, portable and reprogrammable logger. A national workshop should be conducted to examine digital-based data collection from commercial fishing vessels. Partnerships with private manufacturers should be evaluated.

Designing a Multiuse "Real Time" Website The prototype GIS-based website should be developed and tested to ensure security, privacy, reliability, and to accommodate multiple users.

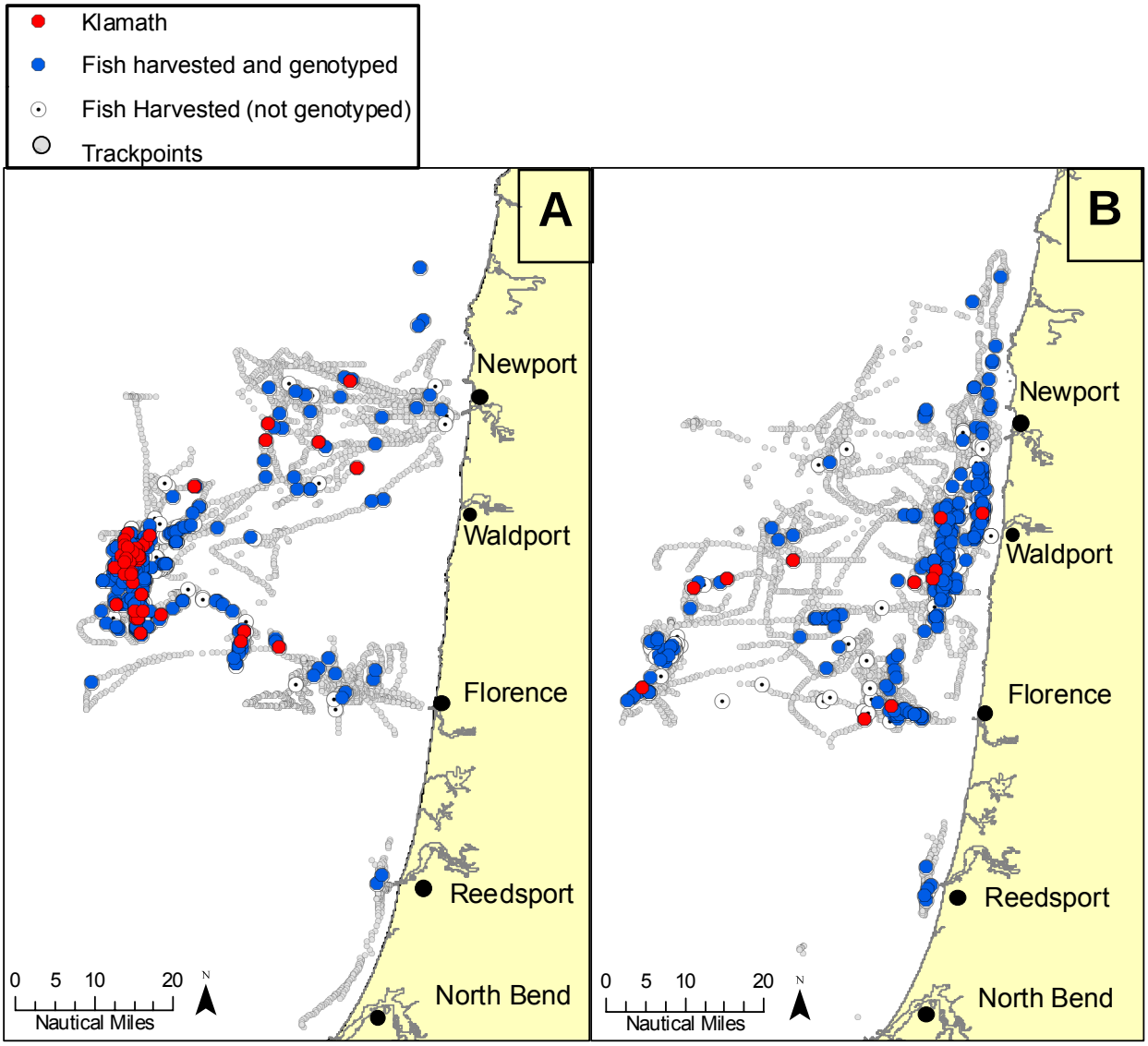
Using Barcodes, Traceability, and the Website to Improve Salmon Marketing Test markets should be conducted that "link" individual harvest information from producers to consumers, enhance market development, and minimize fraud.

Developing and Testing GSI-based Salmon Management Models Management models should be developed that incorporate GSI information. Management simulations should be conducted with salmon managers in "real time" to evaluate in-season management approaches. Bioeconomic models should evaluate GSI information and industry incentives for improving management of the salmon fishery.

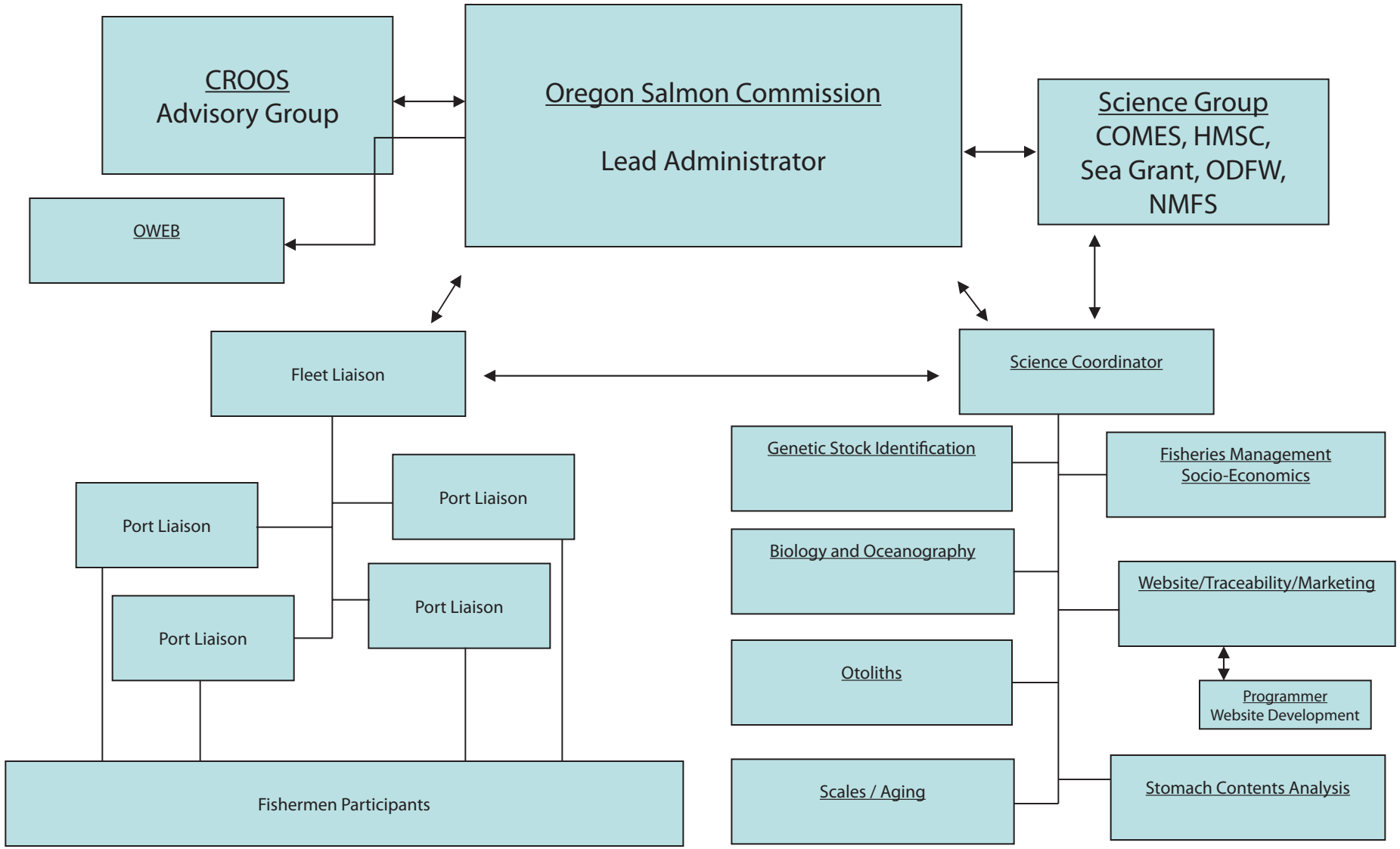
Genetic estimates of stock mixture proportions of Chinook salmon (n = 2567) harvested off the coast of Oregon during the 2006 Project CROOS pilot study. Mixture proportions were estimated using the GAPS (Genetic Analysis of Pacific Salmonids) standardized microsatellite baseline v2 with 166 populations combined into 44 reporting regions and program GMA (Kalinowski 2003).



Time series for fish harvested off the Coast of Oregon during two weeks in 2006. The week of September 17 - 23 (A) yielded 1173 fish sampled with 539 usable genotypes. The following week (B), September 24-30, provided 521 fish samples, of which 280 provided sufficient genotypic data. Fish that assigned to the Klamath basin are highlighted in red.



Organizational Chart for OWEB Collaborative Science Project



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INTRODUCTION

By almost any standard, managing West Coast ocean salmon fisheries poses extraordinary challenges. Hundreds of stocks migrate 1000's of ocean miles across two national and seven provincial and state boundaries. Stocks may swim 100's (sometimes 1000's) of miles up freshwater rivers to spawn and reproduce. Their progeny then remain in freshwater before they become juvenile smolts and return to the sea. Some stocks are raised in hatcheries until they become smolts and are released into the natural habitat. In the face of 1) reduced natural freshwater habitat, 2) man-made obstacles limiting migration, and natural changes in the environment, providing commercial, recreational, and cultural-based fishing opportunities has become a daunting challenge.

One of the major tasks in managing salmon fisheries is ensuring access to healthy stocks while protecting weak stocks and meeting stock escapement goals. Because these stocks commingle in ocean, estuarine and freshwater habitats, it is difficult to manage each stock as a distinct unit. The Pacific Fishery Management Council (PFMC) sets opening and closing dates for the commercial troll and recreational seasons, and bases their decisions on a combination of factors including the projected abundance of fish expected to be encountered in a region and the expected stock mixture compositions by area. Current management practices are aimed at reducing impacts to the weakest stock, and seasons and fishable areas are often limited by the "weakest stock" present in an otherwise healthy fishery.

In 2005 and subsequent years, concerns over the Klamath River fall run was the most constraining factor limiting harvest between Cape Falcon South to the Mexico/US Border (Pacific Fishery Management Council 2006). A fishery resource disaster was declared in 2006 by the Secretary of Commerce, and a complete closure spanning from Cape Falcon, Oregon to Point Sur, California was only avoided in a collaborative effort by the National Marine Fisheries Service (NMFS), Council, state and tribal representatives to identify a scientific basis to allow a limited fishing season. Nevertheless fishing opportunities were severely curtailed resulting in the loss of 100's of jobs and millions of dollars in annual coastal income.

Currently, the estimated contribution of Klamath stock to commercial troll and recreational fisheries is based on a complex model that uses, among other parameters, coded wire tag (CWT) data obtained from current and previous seasons. To date, detailed and specific information on timing of return and oceanic distribution of this and other stocks encountered off the Coast of Oregon and California are unknown. However, recent development of a genetic database known as GAPS (Genetic Analysis of Pacific Salmonids) provides new opportunities to identify the *genetic stock composition* (GSI) of a mixed stock fishery throughout the season, and to monitor when a particular stock moves in or out of an area being fished. With adequate resources this analysis can be performed rapidly (24-48 hours), allowing for near "real time" monitoring of stocks being impacted by harvesters. Availability of such "real time" data could enable fisheries managers to apply in-season adjustments to areas -- closing areas when impact levels of stocks of concern are exceeded and re-directing fishery efforts towards stocks of harvest intent. It may also provide new opportunities for new longer term management alternatives if there are discernable patterns of stock movement and migration over time.

Development of Project CROOS

In the summer of 2005, members of Oregon's Congressional delegation became concerned about the Klamath crisis and impacts on coastal communities. They asked Oregon State University (OSU) for help in finding science-based solutions to this complex problem. Faculty of the multidisciplinary Coastal Oregon Marine Experiment Station (COMES), in collaboration with the Oregon Salmon Commission and federal and state scientists co-located at the Hatfield Marine Science Center, organized a series of meetings through the fall and winter of 2005-2006 to begin scoping out research ideas. Dr. Michael Banks, a COMES faculty member, fisheries geneticist, and one of the contributors to the GAPS database, suggested designing a project founded on GSI techniques. By early spring 2006, Project CROOS (Collaborative Research on Oregon Ocean Salmon) was born. This informal group included members of the Oregon Salmon Commission (OSC), COMES and other OSU faculty, NOAA fisheries scientists, Oregon Sea Grant (OSG) faculty, members of the Community Seafood Initiative (CSI), faculty from OSU's Astoria Seafood Laboratory, and staff from the Oregon Department of Fish and Wildlife (ODFW). By mid spring a proposal was developed to fund a pilot project and seek out competitive and non-competitive grant funding.

The pilot project was designed to combine basic and applied interdisciplinary science, genetic and oceanographic research, industry and scientist collaboration, and data technology and website development -- while also providing financial assistance to the fleet. This required a high degree of adaptive learning and a fundamental commitment to day-to-day communication and coordination. The CROOS Group adopted a core set of principles to guide their project:

- Authentic collaborative research between industry and scientists based on mutual learning and respect
- Integrated fishing and research activities benefiting fishermen, scientists, and resource managers
- Integrated research and project management using digital technologies
- Creating and managing "real time" data for diverse audiences and uses including fishery science, fishery business management, resource management, seafood marketing, and education.

In mid-Spring of 2006, the Oregon Watershed Enhancement Board asked the CROOS group to develop a research proposal for funding consideration as part of their commitment to assist the Governor in providing salmon disaster assistance. In late June 2006 a nine-month pilot project was approved by the Oregon Legislative Emergency Board and funded by the Oregon Watershed Enhancement Board. Given the narrow window of time, the CROOS group began planning for the project in May and fishermen volunteered their own time to assist in developing the sampling protocols and providing data during the mid-June openers. When the project was formally approved in the last week of June, training sessions had been held, contracts with fishermen signed, and operational protocols refined.

Based substantially on the results of the pilot CROOS project during the summer of 2006, a two-day meeting was convened in early October by the Pacific States Marine Fisheries Commission. The meeting included over forty participants from federal and state agencies for salmon science and management, and representatives from the Oregon, Washington, and California salmon troll industries. The participants agreed to: 1) develop a five-year Experimental Fishing Permit (EFP) for the West Coast that would direct research on ocean salmon science and management using GSI techniques; 2) coordinate research between NMFS laboratories, state agencies, and fishing industries from the three West Coast states; and 3) use the protocols developed by the CROOS project to direct and facilitate cooperative fishery GSI-based science. In order to provide for sampling in otherwise closed areas and times, PFMC discussed and determined that, if needed, an EFP could be issued on an emergency basis. In addition, during the fall-winter of 2006/2007 the CROOS group began coordinating with the California Salmon Council and assisting them in developing a similar project.

OWEB Project Goal and Objectives

Goal

Conduct collaborative and interdisciplinary research that develops protocols using genetic stock identification (GSI) in near "real time" to 1) improve science, management, and marketing of West Coast salmon, 2) minimize harvests of "weak stocks," and 3) enhance economic value of the ocean salmon fishery.

Objectives

- Provide financial assistance to salmon fishermen in exchange for their participation in collecting biological, oceanographic, and fisheries information.
- Develop protocols for fishermen and fleet coordinators/managers for effectively collecting scientific samples and information, supplying and exchanging equipment, and coordinating fleet behavior.
- Conduct near "real time" GSI analysis (24-48 hours after samples and data received) on a minimum of 2,000 harvested salmon.
- Conduct salmon "otolith" chemistry analysis to determine if, and when, Chinook salmon from different stocks resided in waters with similar chemical characteristics.
- Develop digital technologies, bar codes, and "traceability" systems for recording, transmitting, storing, analyzing, and displaying scientific data in near "real time" using "datalogging" equipment, Geographic Information System (GIS) maps, and the Internet.
- Develop a comprehensive website for salmon managers, fishermen, scientists, seafood marketers, consumers, and the public for accessing project information in near "real time."

- Develop methods for collecting oceanographic information and integrate with spatial and temporal fish location and GSI information.
- Consider implications/potential of GSI technologies for improving salmon management.
- Make recommendations for future research and management based on project findings.
- Produce a Final Report

Guide to Report

This comprehensive report summarizes the 2006-2007 OWEB sponsored CROOS research project. The report describes project management and protocols, GSI sampling results, website development, oceanographic research, otolith analysis, scale analysis, and discussion of resource management. The concluding section summarizes results and makes recommendations for future research and development. A series of technical appendices provide key supporting and background information. This comprehensive document should prove valuable to salmon scientists, managers, and industry planning to conduct similar projects.