Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Effects Of Ocean Conditions On The Growth And Survival Of Salmonids

Bonneville project number, if an ongoing project 9157

Business name of agency, institution or organization requesting funding
Columbia River Inter-Tribal Fish Commission

Business acronym (if appropriate) CRITFC

Proposal contact person or principal investigator:

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Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name
N/A			

NPPC Program Measure Number(s) which this project addresses.
NPPC document 97-6, Consideration of ocean conditions in the Columbia River Basin Fish and Wildlife Program

NMFS Biological Opinion Number(s) which this project addresses.
N/A

Other planning document references.

This project increases manager's understanding of the impact of ocean conditions on the growth, survival, and abundance of Columbia Basin salmonids, as called for in NPPC 97-

6 (Considerations of Ocean Conditions in the Columbia River Basin Fish and Wildlife Program), the Columbia River Basin Fish and Wildlife Program FY 1998 Annual Implementation Work Plan Recommendations of the Northwest Power Planning Council (Recommendation 4c) and Wy-Kan-Ush-Me Wa-Kush-Wit.

Subbasin.

None

Short description.

Scale growth of adult chinook and sockeye salmon sampled at Bonneville Dam since 1985 will be used to study the effects of ocean conditions on their growth and survival.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
+	Anadromous fish		Construction		Watershed
	Resident fish		O & M		Biodiversity/genetics
	Wildlife		Production	+	Population dynamics
X	Oceans/estuaries	X	Research	X	Ecosystems
+	Climate	+	Monitoring/eval.	+	Flow/survival
	Other	+	Resource mgmt		Fish disease
			Planning/admin.		Supplementation
			Enforcement		Wildlife habitat enhancement/restoration
			Acquisitions		

Other keywords.

scales, growth

Section 3. Relationships to other Bonneville projects

Project #		Nature of relationship
0		

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Correlate Columbia Basin spring chinook and sockeye salmon scale growth with changes in ocean conditions.	a	Assemble scales and construct data sets for sockeye and chinook salmon for 1985-1997 (most of which are in CRITFC archives)
2		b	For each scale sample to be analyzed, measure distances from focus to circuli, ocean entry, and freshwater and ocean annuli.
		c	Assemble data on ocean conditions
		d	Analyze life history data in relation to ocean conditions
		e	Draft Report
		f	Report publication
2	Correlate changes in Columbia Basin spring chinook and sockeye salmon scale growth with run size and fish size.		Same tasks as 1a to 1f
3	Estimate ocean conditions for different stocks of Columbia Basin sockeye and chinook salmon.		Same tasks as 1a to 1f
4	Estimate the freshwater growth advantage in relation to ocean growth		Same tasks as 1a to 1f
5	Quantify different growth rates between wild and hatchery fish.		Same tasks as 1a to 1f

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	10/1998	9/2000	80.00%
2	10/1998	9/2000	5.00%

3	10/1998	9/2000	5.00%
4	10/1998	9/2000	5.00%
5	10/1998	9/2000	5.00%
			TOTAL 100.00%

Schedule constraints.

No constraints are envisioned. The following two major milestones, and projected completion dates, are envisioned:
1.) Completion of measurements of scales, 12/1999
2.) Completion of assembling ocean condition data, 12/1999.

Completion date.
2000

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		$45,993
Fringe benefits		$11,150
Supplies, materials, non-expendable property		$1,000
Operations & maintenance		$0
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		$10,000
PIT tags	# of tags:	$0
Travel		$700
Indirect costs		$17,599
Subcontracts		$0
Other		$0
TOTAL		$86,442

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$28,355			
O&M as % of total	0.00%			

Section 6. Abstract

In recent years, the role that ocean conditions (e.g. El Niño) play in the low abundance of Columbia Basin salmonids has been a source of controversy (e.g. NPPC document 97-6, ISG Return to the River). Poor ocean conditions have been blamed for both low abundance and a reduction in the mean size of returning adults. We propose to assess the impact ocean conditions have on salmon growth, age distribution, and run size through the use of scale patterns. These patterns represent a record of the growth of salmon throughout their life, including the period in the ocean.

CRITFC has sampled scales from sockeye and chinook salmon at Bonneville Dam since 1985. This collection spans years of relatively high salmonid abundance (1985-1988) as well as recent years of low abundance. These years also span periods of widely varying ocean conditions. This project will explore whether the influence of variable ocean conditions on fish growth and run size can be used to refine our understanding of the variability in salmon production. These results will be available to better relate the response of salmon return abundance to different management practices. Specifically, we propose to use scale patterns to explain (and predict) run size and fish size variability and identify whether different Columbia River salmon stocks are exposed to similar or different ocean conditions. This project will provide greater understanding of the impacts of ocean conditions on Columbia Basin salmon.

Section 7. Project description

a. Technical and/or scientific background.

Fishery managers have long made the implicit assumption that the production of adult salmon can be determined and manipulated in direct proportion to the number of juvenile fish supplied to the ocean (NPPC 1997). Regardless of the number of juveniles placed in the ocean, the proportion of returning adults was expected to remain relatively constant. Therefore, attempts to increase run sizes typically focused on increasing the number of fish reaching the ocean (i.e. hatcheries). However in recent years, it has been noted that there is considerable variability in ocean survival (Lawson 1993, Holtby et al. 1990, Mathews and Ishida 1989). Therefore the low abundance of Columbia Basin salmonids has recently been blamed by some on poor ocean survival (e.g. El Niño) rather than problems with freshwater habitat or mainstem passage.

It is important to determine the degree to which changes in ocean habitat affect salmonid survival and growth. Unless ocean conditions are monitored, and their affect on salmonids understood, it is impossible to accurately evaluate how various changes in fish management (fisheries, hatcheries, freshwater habitat improvements) impact salmonid productivity.

The proposed ocean growth research is an extension of the work which CRITFC has conducted annually since the mid 1980's, which examines freshwater growth of

Columbia Basin spring and summer chinook salmon and sockeye salmon. Scale pattern analysis data has been used to determine age and length-at-age composition of spring and summer chinook salmon (Fryer et al. 1992c, 1995; Fryer and Schwartzberg 1991b, 1991c, 1993, 1994; Schwartzberg and Fryer 1989, 1990) and sockeye salmon (Fryer et al. 1992b; Fryer and Schwartzberg 1991a, 1993, 1994; Schwartzberg and Fryer 1988, 1989, 1990). Differences in freshwater growth characteristics, as determined from scale patterns, have been used to differentiate different races and stocks of spring and summer chinook salmon (Fryer and Schwartzberg 1990, 1993; Schwartzberg and Fryer 1989, 1990) and sockeye salmon (Fryer et al. 1992b; Fryer and Schwartzberg 1991a, 1993, 1994; Schwartzberg and Fryer 1988, 1989, 1990). This data has also been used in combination with other studies to determine sockeye salmon survival rates and density dependence effects (Fryer 1995).

b. Proposal objectives.

There are five objectives for this project:

1.) Correlate Columbia Basin spring chinook and sockeye salmon scale growth with changes in ocean conditions.
2.) Correlate changes in Columbia Basin spring chinook and sockeye salmon scale growth with run size and fish size.
3.) Identify whether different Columbia River salmon stocks experience the same or different ocean conditions.
4.) Estimate the freshwater growth advantage in relation to ocean growth.
5.) Quantify different growth rates between wild and hatchery fish.

The first two objectives are the priority for this project. However, once the data is collected for these objective, if becomes relatively easy to examine the other three objectives. In this section, the first two objectives will be discussed together, while the other objects will be treated individually.

Objective 1: Correlate Columbia Basin spring chinook and sockeye salmon scale growth with changes in ocean conditions.

Hypotheses:

H_0: Ocean growth of Columbia Basin sockeye and chinook salmon is not affected by ocean conditions.

H_A: Ocean growth of Columbia Basin sockeye and chinook salmon is affected by ocean conditions.

Assumption necessary to test this hypothesis:

None

Objective 2: Correlate changes in Columbia Basin spring chinook and sockeye salmon scale growth with run size and fish size.

Hypotheses:

H_0: Columbia Basin sockeye and chinook salmon run sizes and fish size are not affected by ocean conditions.

H_A: Columbia Basin sockeye and chinook salmon run sizes and fish size are affected by ocean conditions.

Assumption necessary to test this hypothesis:
None

Sockeye and spring chinook scales will be used to search for correlations in ocean growth and run sizes, mean fish sizes, and age at return. Sockeye salmon scale samples originate from two stocks (Wenatchee and Okanogan) while spring chinook scale samples originate from all stocks upstream of Bonneville Dam. Variability in natural mortality and growth in the ocean is not well understood. However, it is an important component of run variability. Unless the sources of variability are well understood, it is difficult to predict the run sizes in the Columbia River and the response of the salmon populations to management actions. The expected output of this activity is a better understanding of the variability in run size in response to management action in the Columbia Basin, and an increased predictive ability from models incorporating ocean conditions.

Fishery managers, to a large extent, predict run sizes by using the number of fish which have previously returned from the same brood class. For example, the number of three year olds from the 1994 brood year returning in 1997 is used to predict the number of four-year-olds returning in 1998. However, the number of returning fish often deviate significantly from these predictions. "Ocean conditions" tends to be the catch-all reason for these deviations. Any change in "ocean conditions" should be reflected in the scale patterns of returning salmonids. Poor ocean conditions should mean fewer circuli and/or less scale growth between annuli. We are hypothesizing that this interannual change in growth can be correlated with both salmon run size and fish size. It may also be possible to correlate the interannual change in growth with changes in the age composition of returning fish. For example, poor ocean growth may result in fish delaying their maturation as a result of slower growth. (On the other hand, poor ocean conditions may result in increased mortality, meaning fewer fish returning at older age classes.) The expected output is a more accurate model for predicting returns from verification of the hypothesis that decreased ocean growth results in an increased proportion of fish returning at older ages. These parameters are required for the development of predictive tools (e.g. cohort analysis, climate change).

To allow fishery managers to predict changes in fish abundance and sizes, we will correlate historical oceanographic data with spring chinook and sockeye salmon abundance and growth. We will obtain historical oceanographic data, such as sea-surface temperature and barometric temperature (Woodruff et al. 1987) and determine if these can be used to explain differences in abundance and growth.

Objective 3: Identify whether different Columbia River sockeye salmon stocks experience the same or different ocean conditions

Hypotheses:

H_0: Columbia Basin sockeye salmon Okanogan and Wenatchee stocks experience similar ocean conditions.

H_A: Columbia Basin sockeye salmon Okanogan and Wenatchee stocks experience different ocean conditions.

Assumption necessary to test this hypothesis:

None

This activity could provide an improved understanding of natural variability in response to management action in the Columbia Basin by searching for between-stock variability in ocean growth. This could result from stock-specific differences in ocean growth or from different stocks living in different portions of the ocean. This study will be done with sockeye salmon scale samples whose stock origin can be estimated using their age and freshwater scale patterns.

Objective 4: Estimate the freshwater growth advantage in relation to ocean growth

Hypotheses:

H_0: Ocean growth is independent of freshwater growth.

H_A: Ocean growth is not independent of freshwater growth.

Assumption necessary to test this hypothesis:

None

It has been postulated for many years by hatchery operators and supplementation studies that an initial growth advantage of juvenile salmon in the freshwater phase will result in lower mortality (e.g. reduced predation) and will give the fish a competitive advantage as well as energy reserves for the oceanic part of the life cycle. Growth, as estimated from scales, will be related to the freshwater and oceanic growth components of the life cycle in both wild and hatchery fish. The expected output is a relationship between freshwater and ocean growth. The cost of boosting juvenile growth rates can be evaluated at an ecological level, and lead to recommendations on optimal size, potentially resulting in large-scale savings in hatchery operations, and optimization of production potential.

Objective 5: Quantify different ocean growth rates between wild and hatchery spring chinook salmon.

Hypotheses:

H_0: Hatchery and wild spring chinook salmon have similar ocean growth rates.

H_A: Hatchery and wild spring chinook salmon have different ocean growth rates..

Assumptions necessary to test this hypothesis:

The scale patterns of adipose clipped spring chinook salmon are representative of those of all hatchery spring chinook salmon.

The scale patterns of spring chinook salmon determined to be of wild origin are representative of those of all wild spring chinook salmon.

The proportion of adipose clipped spring chinook salmon has ranged 8% to 55% of the fish we have sampled at Bonneville Dam. Virtually all adipose clipped fish are of hatchery origin. Visual analysis of scale patterns will be used to obtain a sample of wild spring chinook salmon.

c. Rationale and significance to Regional Programs.

The overall objective of the FWP is to recover salmonid runs in the Columbia Basin. However, any action which is undertaken may be either undermined or enhanced by conditions in the ocean. This project seeks to determine whether scale patterns can be used as a way to measure ocean conditions. This information could then be factored into determining the effect of other measures.

d. Project history

N/A

e. Methods.

Sampling Methods

Scale samples used will be those previously collected by CRITFC at the Bonneville Dam Fisheries Engineering and Research Laboratory. These scale samples are representative of the spring chinook and sockeye salmon populations, being collected one to three times weekly throughout the migratory period of runs. Sockeye salmon scale samples have been collected since 1985 while spring chinook salmon scale samples have been collected since 1987. Length measurements and fin clip presence was also recorded for all fish. These scale samples were placed on glue-coated cards. Impressions were later made on acetate using a press.

The number of fish from which we have scale samples in CRITFC archives is as follows:

Year	Sockeye Salmon	Spring Chinook Salmon
1985	440	
1986	391	
1987	393	364
1988	510	535
1989	543	511
1990	747	704
1991	855	385
1992	751	504
1993	716	629
1994	234	479
1995	329	392
1996	525	795
1997	631	860

Sample Design

Age Determination and Scale Measurements

Salmon scales, under magnification, display numerous concentric rings (*circuli*) radiating outwards from a central focal area. A freshwater-growth zone of narrowly spaced circuli is distinguishable from a zone of more widely space saltwater-growth circuli in scales of all Columbia Basin salmonids. Typically, sockeye salmon spend one or two complete years in freshwater before migrating to the ocean, while chinook salmon spend either zero or one complete year in freshwater. Fish age can be determined by counting *annuli*, which are zones of closely spaced circuli formed yearly during winter periods of slow growth. The age of all samples to be examined in this study have been previously determined.

A computer and video camera will be used to measure, or *digitize*, scale features (BioSonics 1985). One scale from each fish will be selected, oriented diagonally with the clear (posterior) part of the scale in the lower left corner of the screen, and a reference line will be drawn along its base. A radial line will then be drawn perpendicular to the reference line, and circuli positions measured at their points of intersection with the radial line. Additional circuli markers will be placed to permit measurement of other key scale-features such as annuli and point of saltwater-entry. The distances from the focus to each circuli or key scale feature will be measured (Fryer 1995).

It is anticipated that one scale from most, if not all, sockeye and spring chinook samples in CRITFC archives will be measured for ocean growth. If results from these scale samples are encouraging, and time and budget permit, we will also search out other sources of scale samples (ODFW, WDFW) in an effort to extend our time series into the early 1980's or 1970's.

Analysis

Correlation coefficients will be the primary statistic used in data analysis. Ocean growth will be correlated with run sizes and fish lengths. Ocean growth patterns will also be correlated with indices of ocean condition. Regression techniques will be used to incorporate ocean growth into run prediction models.

f. Facilities and equipment.

This project requires office space and computer equipment capable of digitizing scales and analyzing the resulting data. The office space is available at CRITFC. The scale digitizing equipment we presently use to perform freshwater analyses of scales (BioSonics 1985) probably will be inadequate for the analysis of an entire scale due to insufficient resolution. Therefore, we expect that we will need to purchase a new system.

g. References.

Fryer, J.K. 1995. Columbia Basin sockeye salmon-causes of their past decline, factors contributing to their present low abundance, and the future outlook. Ph.D. Dissertation. University of Washington, Seattle.

Fryer, J.K., and M. Schwartzberg. 1990. Experiments in identifying hatchery and naturally spawning stocks of Columbia Basin spring chinook salmon using scale pattern analysis. Columbia River Inter-Tribal Fish Commission Technical Report 90-4, Portland.

Fryer, J.K., and M. Schwartzberg. 1991a. Identification of Columbia Basin sockeye salmon stocks based on scale pattern analyses, 1990. Columbia River Inter-Tribal Fish Commission Technical Report 91-2, Portland.

Fryer, J.K., and M. Schwartzberg. 1991b. Age and length composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1990. Columbia River Inter-Tribal Fish Commission Technical Report 91-1, Portland.

Fryer, J.K. and M. Schwartzberg. 1991c. Age and length composition of Columbia Basin summer chinook salmon sampled at Bonneville Dam in 1990. Columbia River Inter-Tribal Fish Commission Technical Report 91-4, Portland.

Fryer, J.K. and M. Schwartzberg. 1993. Age and length composition of Columbia Basin spring and summer chinook salmon at Bonneville Dam in 1992. Columbia River Inter-Tribal Fish Commission Technical Report 93-1, Portland.

Fryer, J.K. and M. Schwartzberg. 1993. Identification of Columbia Basin sockeye salmon stocks using scale pattern analyses in 1992. Columbia River Inter-Tribal Fish Commission Technical Report 93-2, Portland.

Fryer, J.K. and M. Schwartzberg. 1994. Age and length composition of Columbia Basin spring and summer chinook salmon at Bonneville Dam in 1993. Columbia River Inter-Tribal Fish Commission Technical Report 94-1. Portland.

Fryer, J.K. and M. Schwartzberg. 1994. Identification of Columbia Basin sockeye salmon stocks using scale pattern analyses in 1993. Columbia River Inter-Tribal Fish Commission Technical Report 94-2, Portland.

Fryer, J.K., D. R. Pederson, and M. Schwartzberg. 1995. Age and length composition of Columbia Basin spring and summer chinook salmon at Bonneville Dam in 1994. Columbia River Inter-Tribal Fish Commission Technical Report 95-1.

Fryer, J.K., C.E. Pearson, and M. Schwartzberg. 1992a. Identification of Columbia Basin sockeye salmon stocks based on scale pattern analyses, 1991. Columbia River Inter-Tribal Fish Commission Technical Report 92-2, Portland.

Fryer, J.K., C.E. Pearson, and M. Schwartzberg. 1992b. Age and length composition of Columbia Basin spring chinook salmon at Bonneville Dam in 1991. Columbia River Inter-Tribal Fish Commission Technical Report 92-1, Portland.

Fryer, J.K., C.E. Pearson, and M. Schwartzberg. 1992c. Age and length composition of Columbia Basin summer chinook salmon at Bonneville Dam in 1991. Columbia River Inter-Tribal Fish Commission Technical Report 92-4, Portland.

Holtby, L.B., Andersen, B.C., Kadowski, R.K. 1990. Importance of smolt size and early ocean growth to interannual variability in marine survival of coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Science. 47:2181-2194.

Lawson, P.W. 1993. Cycles in ocean producivity, trends in habitat quality, and the restoration of salmon runs in Oregon. Fisheries 18: 6-10.

Mathews, S.B. and Y. Ishida. 1989. Survival, ocean growth, and ocean distribution of differentially timed releases of hatchery coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Science. 46:1216-1226.

Northwest Power Planning Council. 1997. Consideration of ocean conditions in the Columbia River Basin Fish and Wildlife Program. NPPC document 97-6, dated May 29, 1997. Portland.

Schwartzberg, M. and J.K. Fryer. 1988. Identification of Columbia Basin sockeye salmon stocks based on scale pattern analyses, 1987. Columbia River Inter-Tribal Fish Commission Technical Report 88-2. Portland.

Schwartzberg, M. and J.K. Fryer. 1989. Age and length composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1988. Columbia River Inter-Tribal Fish Commission Technical Report 89-1. Portland.

Schwartzberg, M. and J.K. Fryer. 1989. Experiments in identifying hatchery and naturally spawning stocks of Columbia Basin spring chinook salmon using scale pattern analyses. Columbia River Inter-Tribal Fish Commission Technical Report 89-3. Portland.

Schwartzberg, M. and J.K. Fryer. 1989. Identification of Columbia Basin sockeye salmon stocks based on scale pattern analyses, 1988. Columbia River Inter-Tribal Fish Commission Technical Report 89-2. Portland.

Schwartzberg, M. and J.K. Fryer. 1990. Age and length composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1989. Columbia River Inter-Tribal Fish Commission Technical Report 90-1. Portland.

Schwartzberg, M. and J.K. Fryer. 1990. Identification of Columbia Basin sockeye salmon stocks based on scale pattern analyses, 1989. Columbia River Inter-Tribal Fish Commission Technical Report 90-2. Portland.

Schwartzberg, M. and J.K. Fryer. 1993. Identification of hatchery and naturally spawning Columbia Basin spring chinook salmon using scale pattern analyses. North American Journal of Fish Management. 13: 263-261

Woodruff, S.D., R. J. Slutz, R. L. Jeffe, and P.M. Steurer. 1987. A comprehensive ocean-atmosphere data set. Bull. Amer. Meteor. Soc. 68: 1239-1250.

Section 8. Relationships to other projects

This project complements CRITFC's existing Pacific Salmon Treaty funded stock identification work. As part of this work, we have amassed a large collection of scale samples, determined their age, and analyzed freshwater growth of a portion of the scale samples. The project proposed for BPA funding would allow for further analysis of existing data, thereby greatly increasing the knowledge we can obtain, but without requiring the acquisition of (expensive) data.

Section 9. Key personnel

Key Project Personnel and Duties

Jeff Fryer is project leader and will be supervising the data collection, data organization, determination of sample sizes, and measuring of scales. He will also be responsible for the analysis of the results and the publication of results.

André Talbot will supervise the collection of historical oceanographic data and assist in the sample design of this study, as well as the analysis of the results and the publication of results.

Jeffrey K. Fryer

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Education

1995 University of Washington. Ph.D. (Fisheries).

1985 University of New Brunswick at Fredericton, New Brunswick, Canada. MSc(Computer Science).

1979 University of New Brunswick at Fredericton. BSc(Computer Science) with the equivalent of an honors in Statistics and a minor in Economics.

Relevant Publications

Fryer, J.K. In press. Frequency of pinniped-scars and wounds on adult spring-summer chinook and sockeye salmon returning to Bonneville Dam. North American Journal of Fisheries Management.

Fryer, J.K. 1995. Columbia Basin sockeye salmon-causes of their past decline, factors contributing to their present low abundance, and the future outlook. Ph.D. Thesis. University of Washington, Seattle.

Fryer, J.K. and P.R. Mundy. 1993. Determining the relative importance of survival rates at different life history stages on the time required to double adult salmon populations, p. 219-223. *In* R. J. Gibson and R.E. Cutting [ed.] Production of juvenile Atlantic salmon, *Salmo salar*, in natural waters. Canadian Special Publication in Fisheries and Aquatic Sciences 118.

Schwartzberg, M. and J.K. Fryer. 1993. Identification of hatchery and naturally spawning Columbia Basin spring chinook salmon using scale pattern analyses. North American Journal of Fish Management. 13: 263-261

Employment

October 1989 to present: Fisheries scientist and project leader at the Columbia River Inter-Tribal Fish Commission. Duties have included the supervision of sockeye and chinook salmon stock identification projects. This has required designing and implementing stock identification experiments, field sampling, creating computer programs, spreadsheets, and databases to manage and analyze data, estimating age composition of salmonids from scale patterns, and publishing technical reports and journal articles.

September 1985 to September 1989: Graduate research and teaching assistant at the University of Washington. Duties included teaching an introductory computer course and assisting the teaching of statistics courses and calculus.

ANDRÉ TALBOT, *Ph.D.*

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EXECUTIVE SUMMARY

Since 1980, I have developed a broad expertise in biostatistics, population dynamics and quantitative genetics in an international development framework. I have a particularly strong background in linking environmental data with variability in production, producing habitat-based predictive models of fish production for major rivers in Eastern Canada. My research education and experience provide the necessary skills for a critical appraisal of methodologies employed in sampling designs, monitoring systems, research programs and resource management. I also have extensive experience in length-based analytical and statistical fisheries methods. From the design of experiments to data collection to statistical analysis, I have assisted tropical and temperate research teams to develop research programs and management plans for integrated aquaculture as well as traditional and industrial fisheries operations. I have also been active in teaching, through workshops and university courses.

EDUCATION

- Ph.D. (Biology) in population dynamics, with emphasis on modelling and statistical methods. Dalhousie University, Biology Dept. 1994. THESIS: Habitat-dependence of population abundance and variability in juvenile Atlantic Salmon (*Salmo salar*).
- M.Sc. (Biology), in evolutionary ecology. McGill University, Biology Dept., 1983.
- B.Sc. Honours (Biology) in ecology and systematics, with graduation *Cum laude*. University of Ottawa, Biology Department, 1980.

SELECTED PUBLICATIONS

TALBOT, A. 1994. Habitat-dependence of population abundance and variability in juvenile Atlantic Salmon (*Salmo salar*). Ph.D. Thesis, Dalhousie Univ., Halifax, Nova Scotia, Canada B3H 4J1. 214 pp.

TALBOT, A.J. and R.W. DOYLE. 1992. Statistical interrelation of length, growth, and scale circulus spacing: II. Use of marginal ossification to detect non-growing fish. Can. J. Fish. Aquat. Sci. 49(4):701-707.

TALBOT, A.J. and R.W. DOYLE. 1990. Statistical properties and power of growth estimation using scale microstructure. p. 421-424 in R. Hirano and I. Hanyu (eds.). The Second Asian Fishery Forum. 991 pp. Asian Fisheries Society, Manila, Philippines.

DOYLE, R.W., A.J. TALBOT and R.R. NICHOLAS. 1987. Statistical interrelation of length, growth and scale circulus spacing: appraisal of a growth-rate estimator for fish. Can. J. Fish. Aquat. Sci. 44(9):1520-1528.

Section 10. Information/technology transfer

Technical information obtained from this project will be distributed in the form of a report and publication(s).