Ocean Fishery Management processes: Chinook and Coho salmon

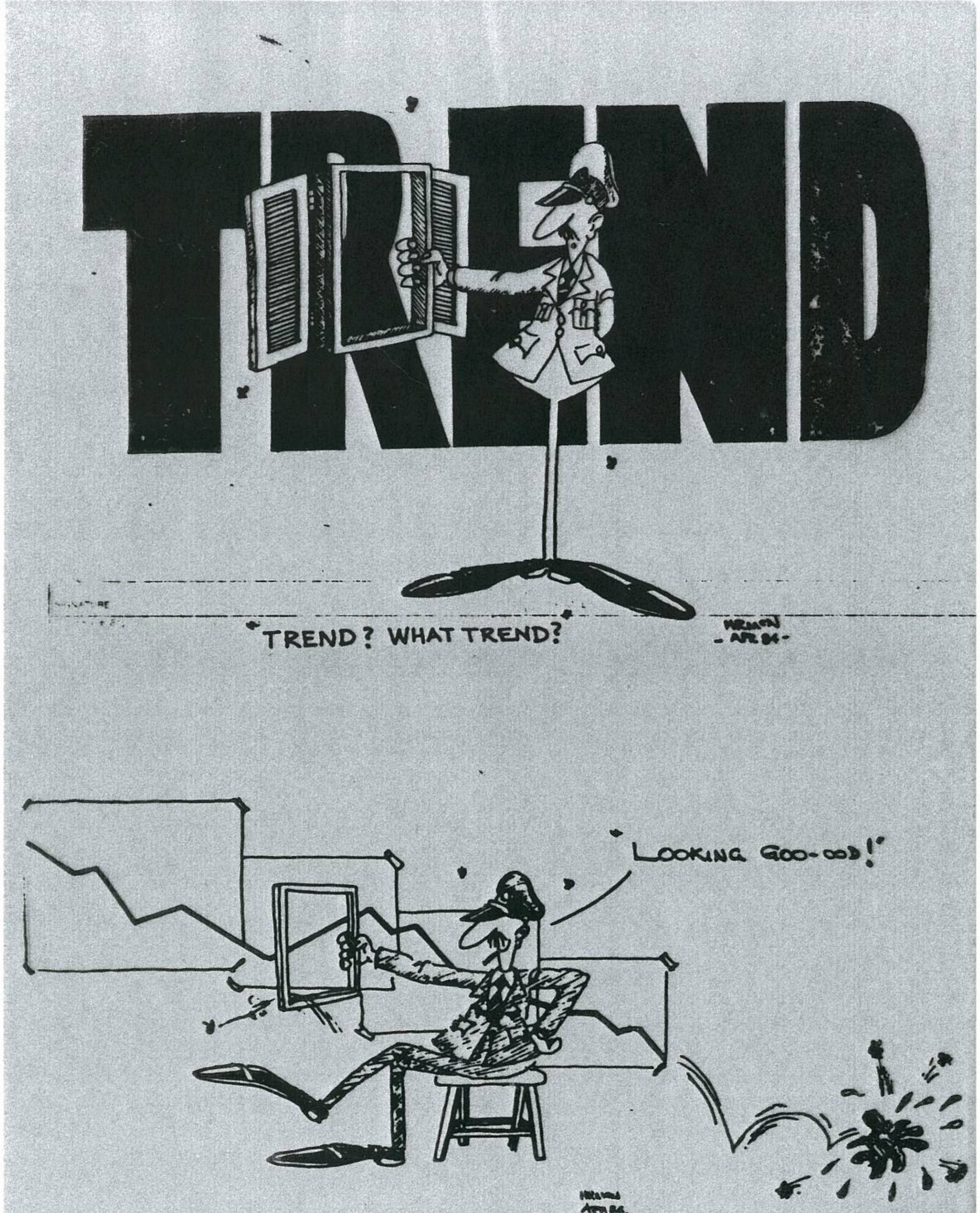
Brian Riddell

Salmon Assessment & Freshwater Ecosystems Division, Science Branch, DFO, Nanaimo, B.C.

Workshop: Current and Future Applications of GSI to Ocean Salmon Management

Portland, OR. May 15, 2007

Hosted by the Pacific Salmon Commission, Vancouver, B.C.



This young Fishery Officer may monitor a "window in time" … but what are the longer term objectives associated with ocean fishery management?

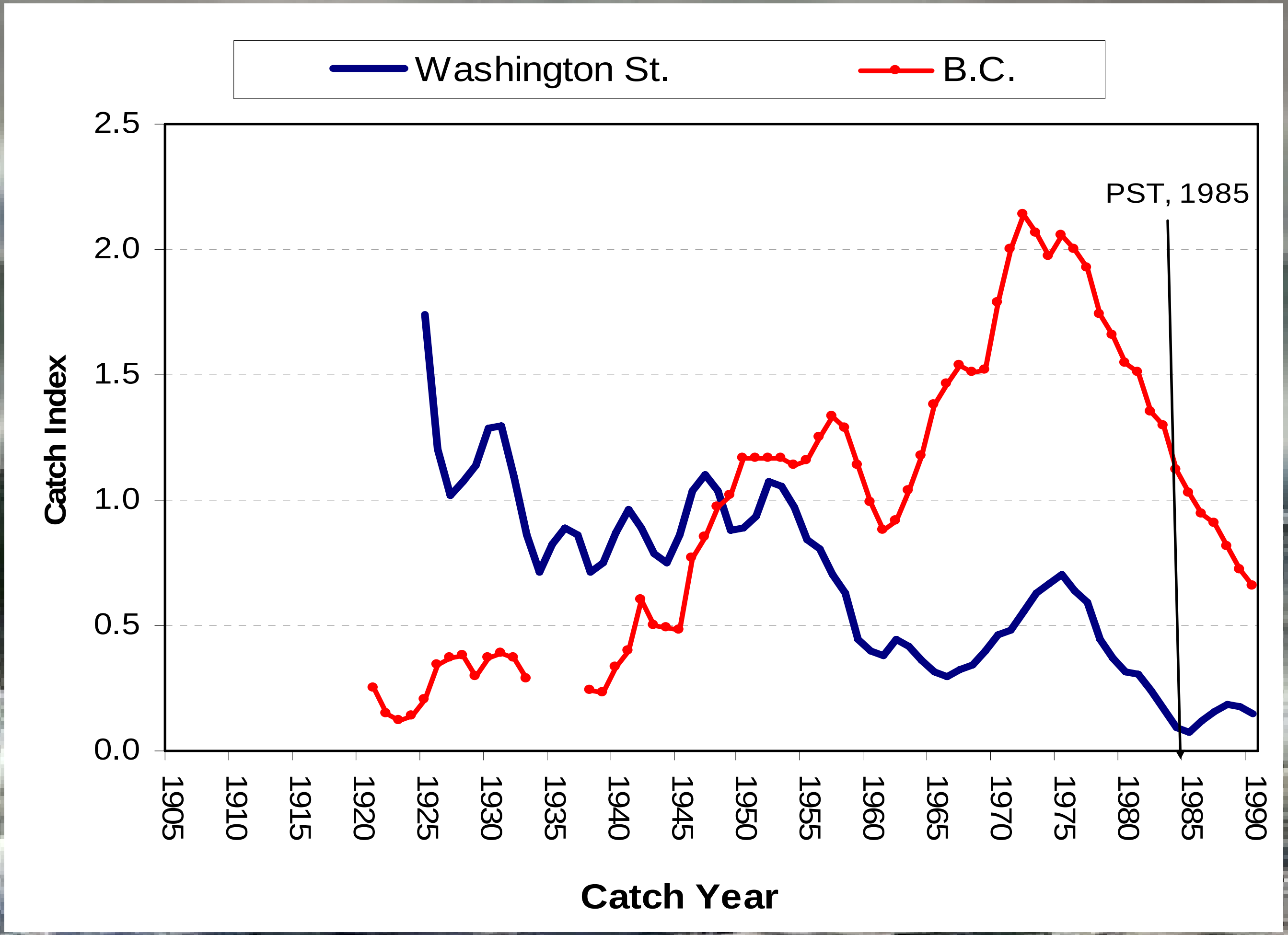
P.S. Is this:

a) C Walters?

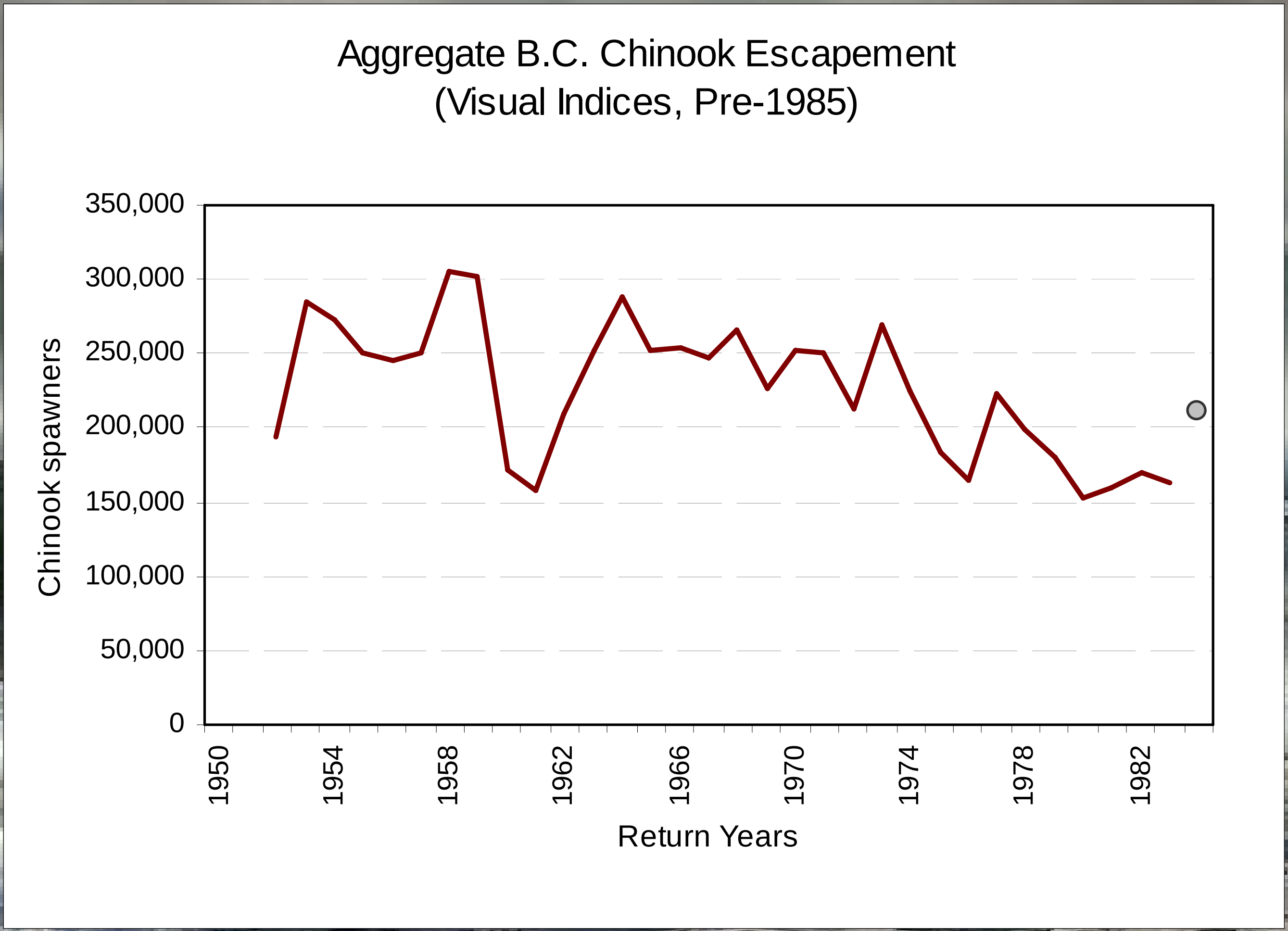
b) R Hilborn?

c) P Starr?

In Pre-PST time (~1985) … ocean management was more stormy than calm, reflecting about 60 years of intensive competitive fisheries, no integrated management process, and severe information limitations resulting in serious impacts on coastal fisheries and spawning stock sizes.



In Pre-PST time (~1985) … ocean management was more stormy than calm, reflecting about 60 years of intensive competitive fisheries, no integrated management process, and severe information limitations resulting in serious impacts on coastal fisheries and spawning stock sizes.



Limitations of Chinook Ocean Management to early 1980's

Stock Assessment:

- majority of harvest in mixed-stock ocean fisheries, harvest on immature and mature fish in multiple sequential fisheries.
- significant incidental (non-landed) mortalities
- hatchery and naturally produced fish confounded in catches
- directed fishing effort by species was unknown
- visual indices of spawning escapements (unknown accuracy or precision), very limited age-structure data by stock (monitoring of trends)
- historical over-fishing limited contrast in stock size and productivity was poorly known (How to relate a spawning index to the catch of a specific stock?)

Fishery Management:

- biological objectives were poorly defined/estimated, management options were limited (time & area closures, size limits) and US/Canada cooperation limited
- uncertainty in data resulted in significant delays in management actions
- cumulative habitat impacts compounded uncertainty
- limited ability for stock identification, some past information based on fin-clipping and external tagging, but building reliance on CWT programs.
- disproportionate impacts on terminal users (U.S. Boldt Decision 1975)

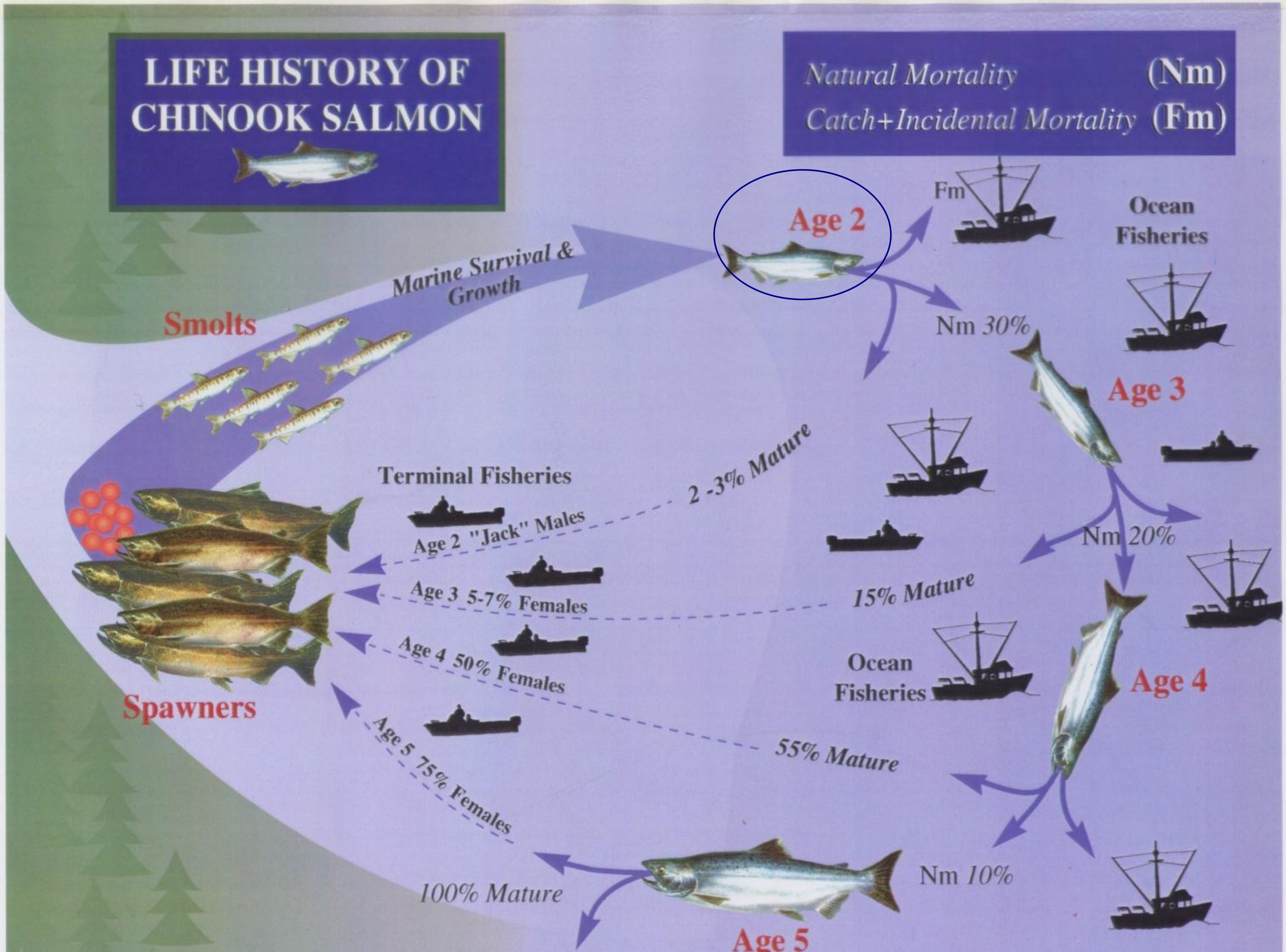
To calm the waters and begin developing an integrated ocean fisheries management regime, we needed:

1) Biological objectives for the naturally-spawning Chinook populations … pretence of defining S_{msy} but seldom estimated for a natural Chinook population.

2) Management objectives for annual conduct of fisheries … how to determine sustainable use, meet allocations between users (international and domestic), and develop pre-season plans (abundance forecasts?)

3) Post-season reviews and ability to provide explanations for discrepancies. Could we even correctly interpret a change in a trend?

Opportunity came from coded-wire tagging of hatchery fish, agreement for a coastwide commercial sampling program, and application of Cohort Analysis to this tag data (early 1980s).



Cohort analysis reconstructs the Age 2 pre-fishery abundance working backwards from the oldest age class in the spawning escapement (assumes values for natural mortality).

Based on the estimated recoveries of CWT in the spawning escapement and all fisheries (recoveries by age), cohort reconstruction provides estimates:

a) Smolt-to-Age 2 survival (numbers of tags released known)

b) Maturation rates by age

c) Distribution patterns by fishery and age, and

d) Exploitation rates by fishery and age (i.e., the portion of the cohort-at-age caught in a specific fishery. Determined for landed catch and/or total fishing mortality.

However, to apply cohort analysis results from hatchery programs to naturally-produced Chinook salmon makes a fundamental assumption …

Hatchery and natural Chinook from local stocks have the same exploitation patterns and rates, and usually the same maturation rates at age.

Example Cohort results: Robertson Creek Fall Chinook, WCVI Natural stock associated with Ocean Exploitation Pattern.

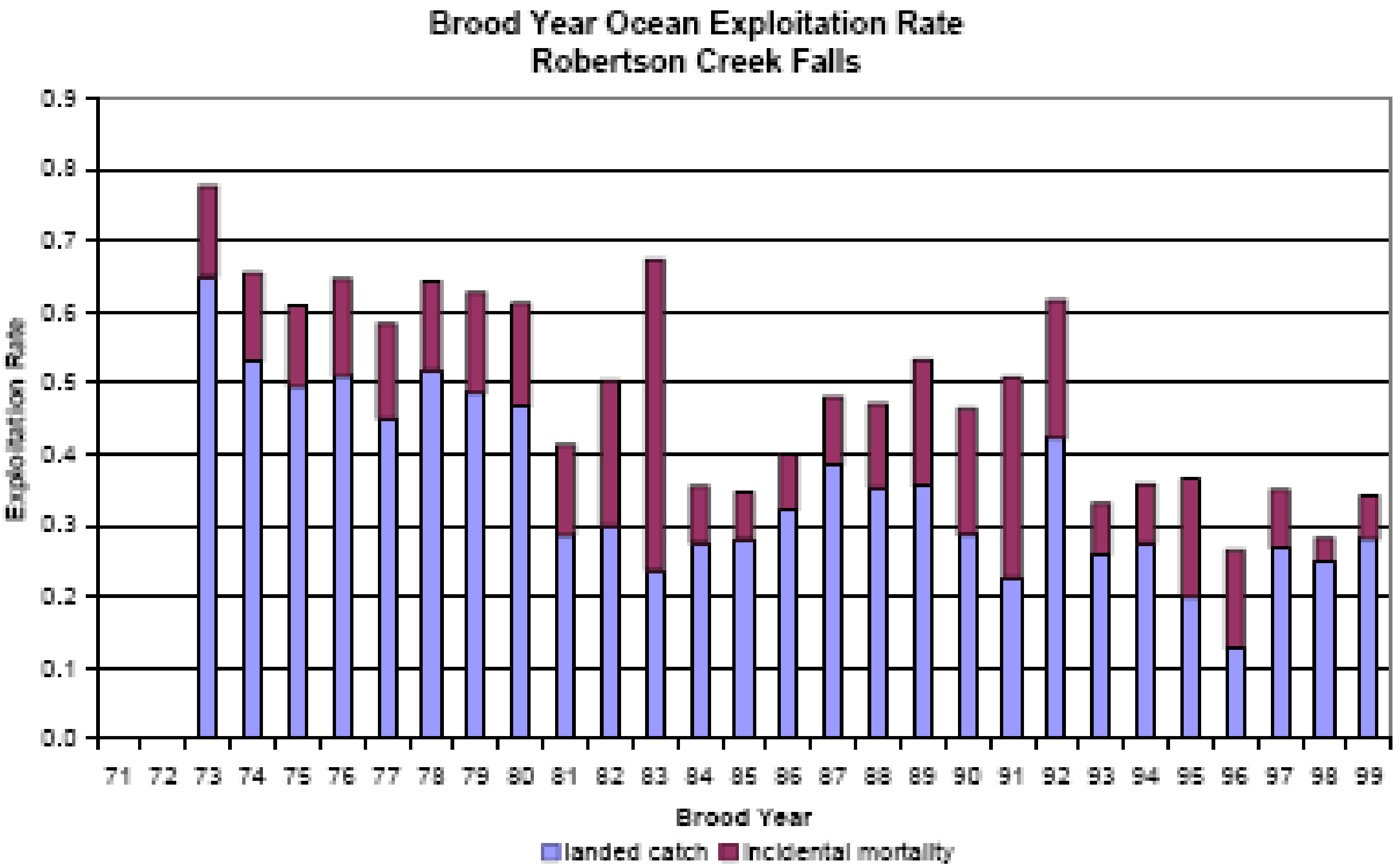


Figure F.3. Robertson Creek Falls (West Coast Vancouver Island Hatchery and Natural) ocean exploitation rates by brood year.

Source: TCCHINOOK 05-3, Appendix F

Assessing a stock over time versus changes in a fishery over time …

Brood years ↓ \ Calendar Years →	1979	1980	1981	1982	1983	1984	1985	1986
1977	2's	3's	4's	5's	6's			
1978		2's	3's	4's	5's	6's		
1979			2's	3's	4's	5's	6's	
1980				2's	3's	4's	5's	6's
1981					2's	3's	4's	5's
1982						2's	3's	4's

Tagging multiple indicator stocks consistently through time provides for:

Stock Indices: comparisons within an indicator over fisheries by age, and

Fishery Indices: comparisons over indicator stocks within fisheries by age.

These indices may be estimated based on CWT data or model derived.

Cohort Analyses applied to the CTC's Coast-wide Chinook Model

Base Period Calibration data (1979-1982 catch years):

1. Cohort analyses (distribution and rates, maturation rates)

2. Annual total catch and escapement for all fisheries and stocks involved in PSC considerations (not all represented by an indicator stock).

3. Enhancement releases (smolt equivalences)

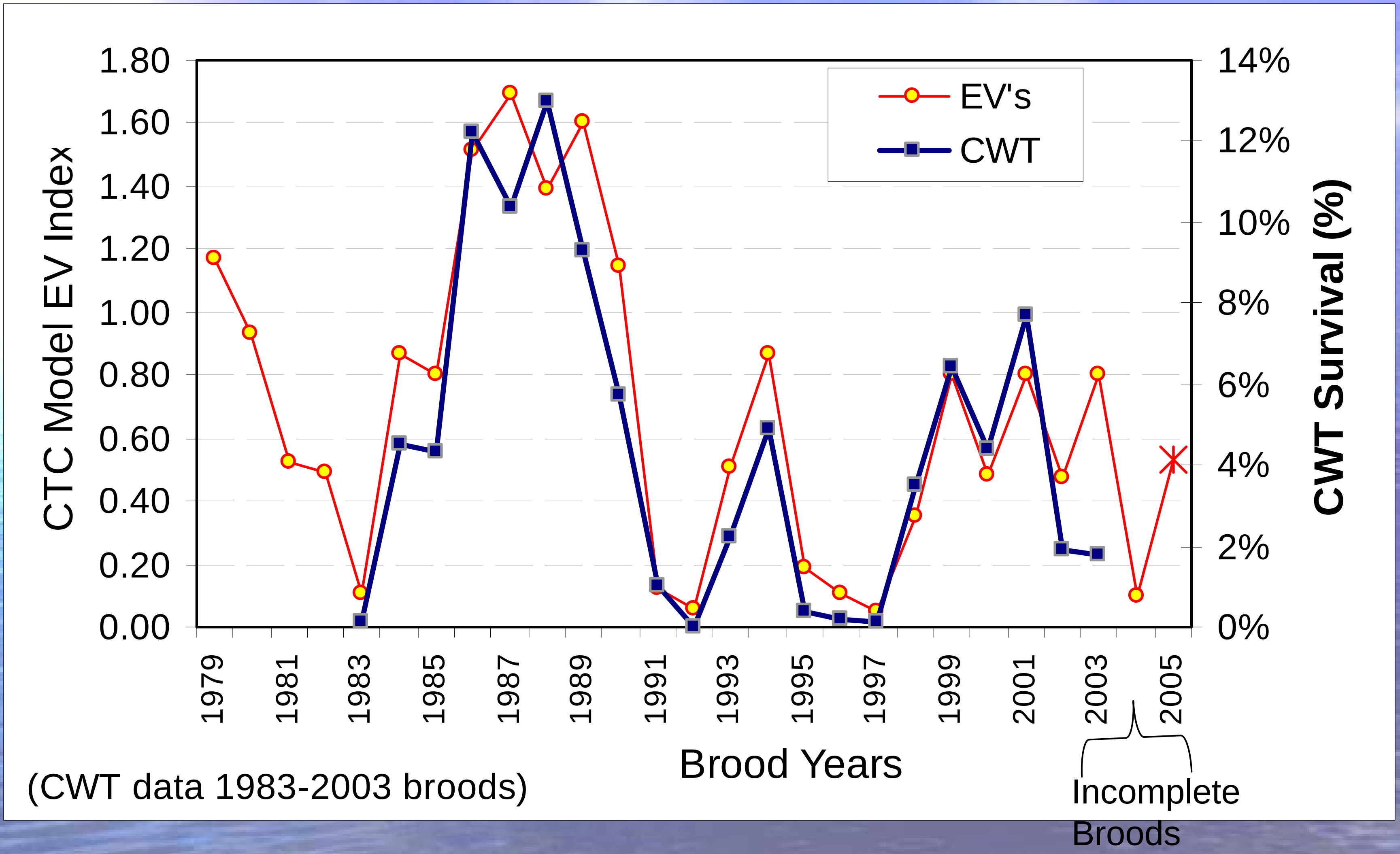
Estimate productivity of natural stocks, each natural stock must be associated with an indicator stock for cohort parameters.

Annual calibration process:

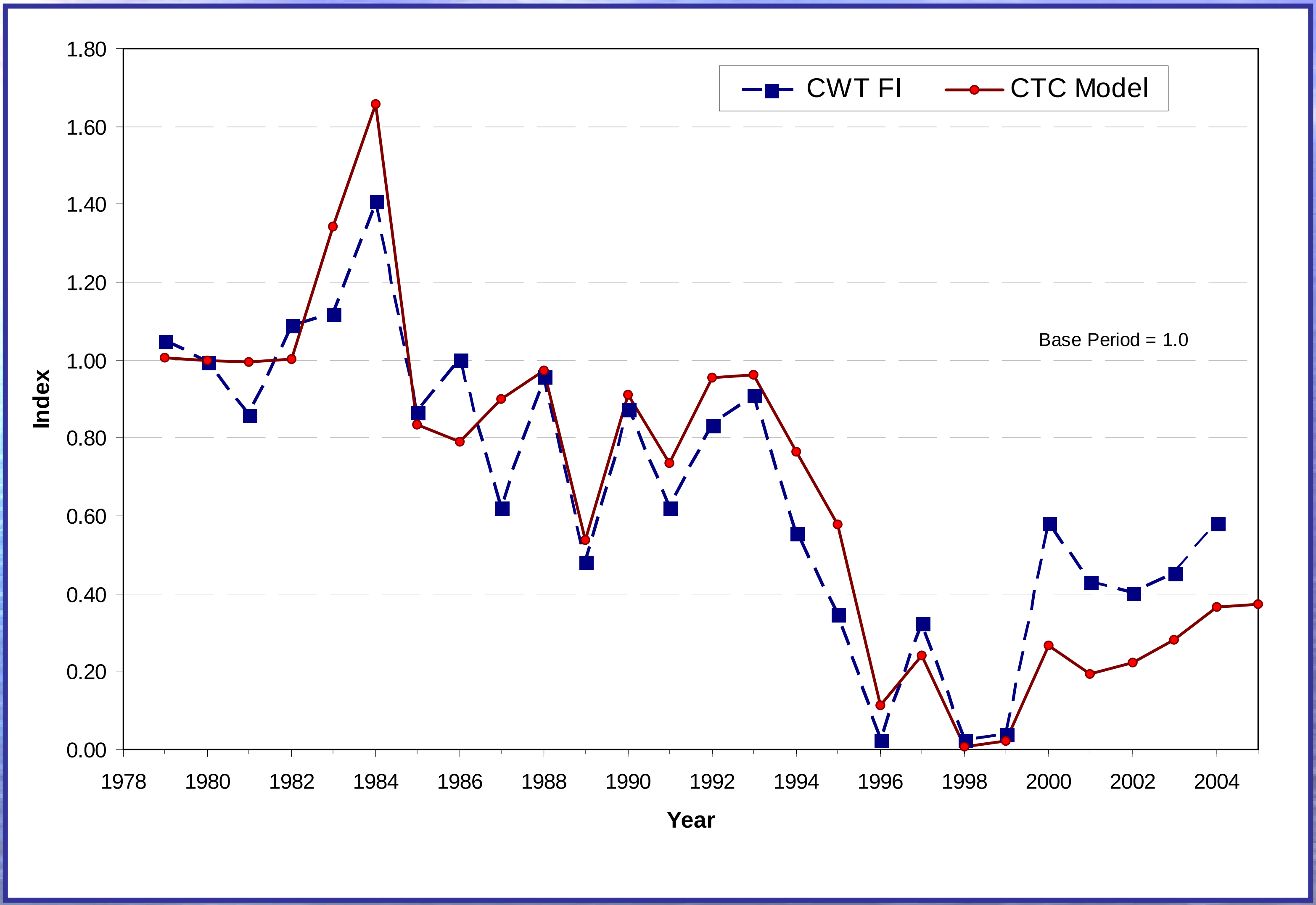
1. **Up-dated for catch and escapements, changes in regulations**
2. **Provision of one-year forecast of abundance by stock**
3. **Estimation of EV's (environmental variable) … adjusts brood production for variation in marine survival (model derived)**
4. **Abundance indices = production by stock * base period distribution; and summed over stocks within a fishery (model).**

Example CWT versus Model comparison: Stock WCVI Hatchery (RCH)

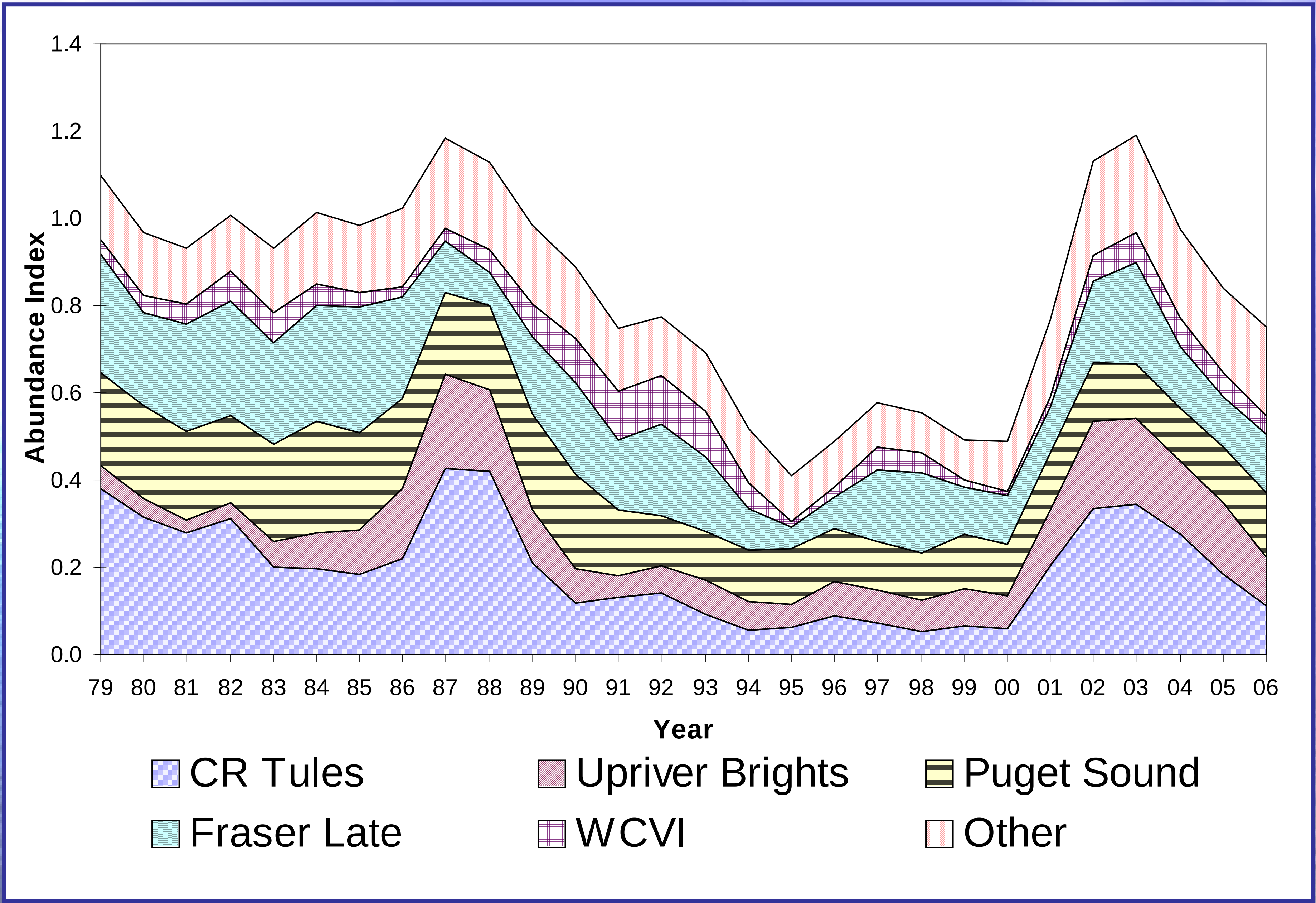
CWT estimated marine survival versus model estimated EV per brood.



WCVI Troll (total mortality index) comparing CWT estimated versus CTC model generated estimate.



WCVI Troll … changes in Abundance Index and Stock Composition (BP fixed)



Under the 1999 PST Agreement, Chinook Ocean Management is based

a) **Two types of fisheries: *<u>Aggregate</u>* Abundance-Based Management (AABM) and Individual Stock-Based Management (ISBM)**

b) **Harvest rates applied vary with Abundance Index in AABM fisheries and are fixed maximum values in ISBM fisheries (if stock of concern are not meeting their escapement goal).**

c) **The Chinook Annex is strongly based on CWT analyses, and historical relationships between catch, abundance, and fishery indices.**

e.g.,

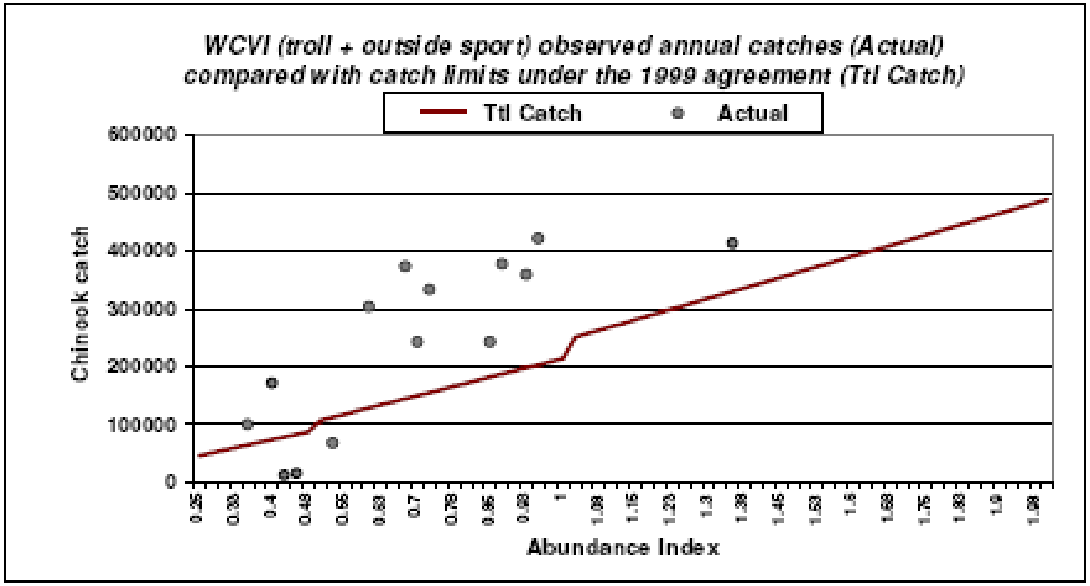


Figure 5. Allowable Catches for WCVI AABM Fisheries. These fisheries include the WCVI troll fishery (Areas 21-27) and the "outside" recreational fishery (as defined in the Agreement).

In the spirit of full disclosure … there are challenges to the CWT program and limitations to the CTC Chinook model.

The CWT program has been increasingly challenged by:

1. **Reduced numbers of observed recoveries due to changes in fisheries, reduced marine survival rates, and limits of sampling coverage.**
2. **Uncertainty increases as harvest rates decrease &/or marine survival decreases without tagging compensation.**
3. **Increased uncertainty due to increased sampling required in spawning escapements, recreational fisheries, and due to regulatory changes in some fisheries (e.g., seasonality of fishery, higher resolution in definition of fisheries).**
4. **Development of mass marking and mark-selective fisheries (Mass marked hatchery groups are no longer representative of natural production).**

More extensive coverage in the Report of the CWT Expert Panel

Limitations of the CTC model include:

1. **Representation of stocks and fisheries … some stocks not represented by tagged indicator, stocks of conservation concern may not be adequately represented, some changes in fisheries can not be represented by base period tag data.**
2. **Cohort analyses and the model currently operate at an annual time scale.**
3. **CTC model has not incorporated the development of mass marking and selective fisheries. Incidental mortality is currently assumed to have the same stock composition as the retained catch.**
4. **The CTC model does not account for uncertainty in data and is currently unable to assess the interactions between fisheries.**
5. **Significant time lags existence between fishery and stock impacts and the ability to assess and/or verify these effects via CWT data or model assessments.**

The application of GSI and CWT data to aid ocean fishery management …

The current PST Agreement for Chinook and Coho is heavily invested in the use of coded-wire tag data, estimation of exploitation rates as management targets, and maintains ocean fisheries on aggregate stock mixtures.

As the PSC approaches another series of negotiations, how could GSI and CWT analyses be better associated to improve the conservation and management of our Chinook and Coho salmon? And, to fully achieve the management potential of these tools, should the PSC examine alternative management regimes during these negotiations?

Ironically, the methods to be discussed in this workshop were actually developing at similar times …

F. Utter and electrophoresis in the late 1960s, and

K. Jefferts and Coded-wire tagging (Jefferts et al. 1963, Nature (London) 198: 460-462.) Coast wide system of tagging and sampling, circa 1975).

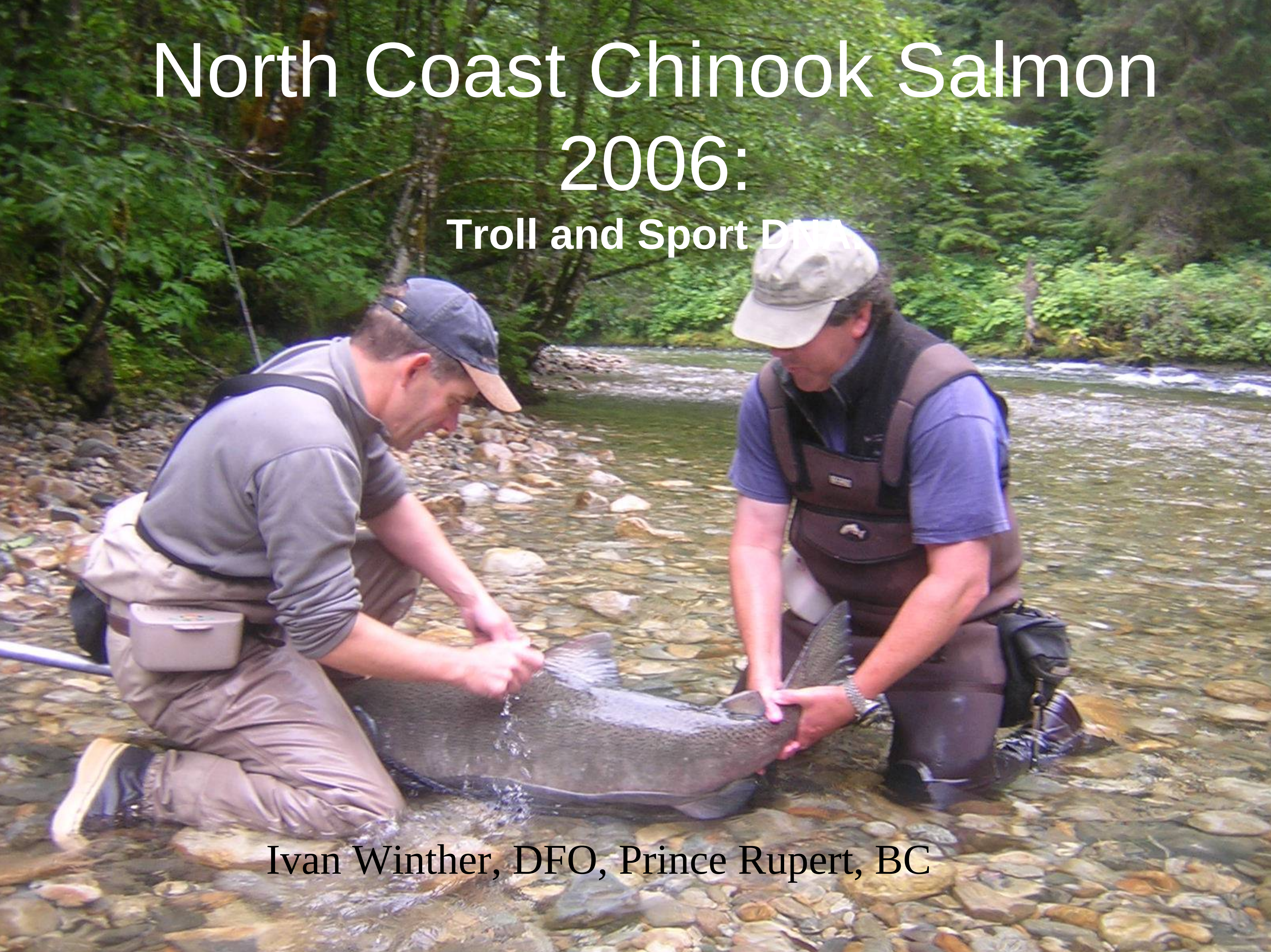
To be fair to past researchers and agency efforts … the application of GSI to Pacific salmon fisheries is not new.

What has been missing is a full integration of GSI capabilities into fishery management and an explicit plan for how to benefit from the potential of these increasingly powerful tools … but

apply it wisely as the costs are incremental at this time.

North Coast Chinook Salmon 2006:

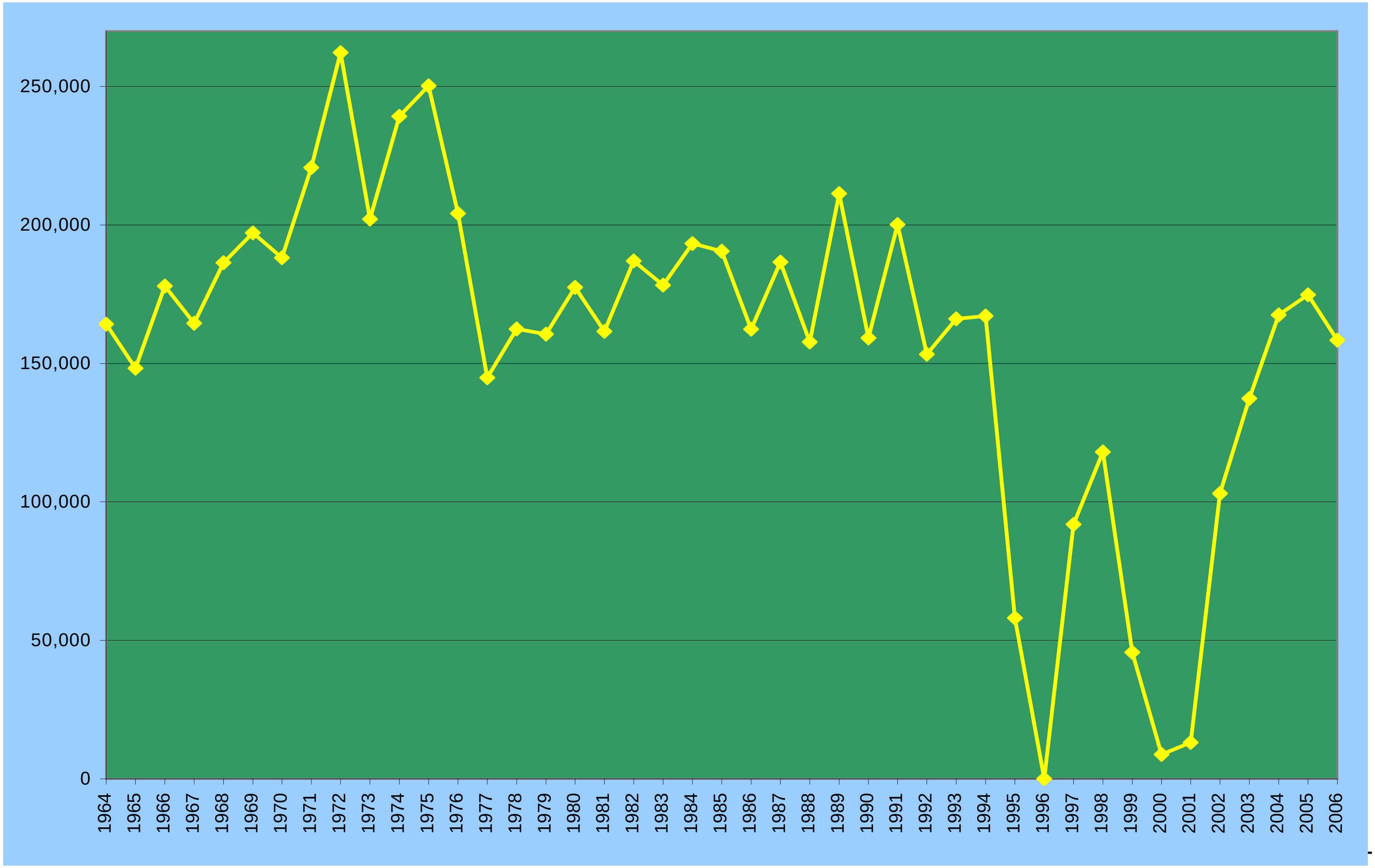
Troll and Sport DNA



Ivan Winther, DFO, Prince Rupert, BC

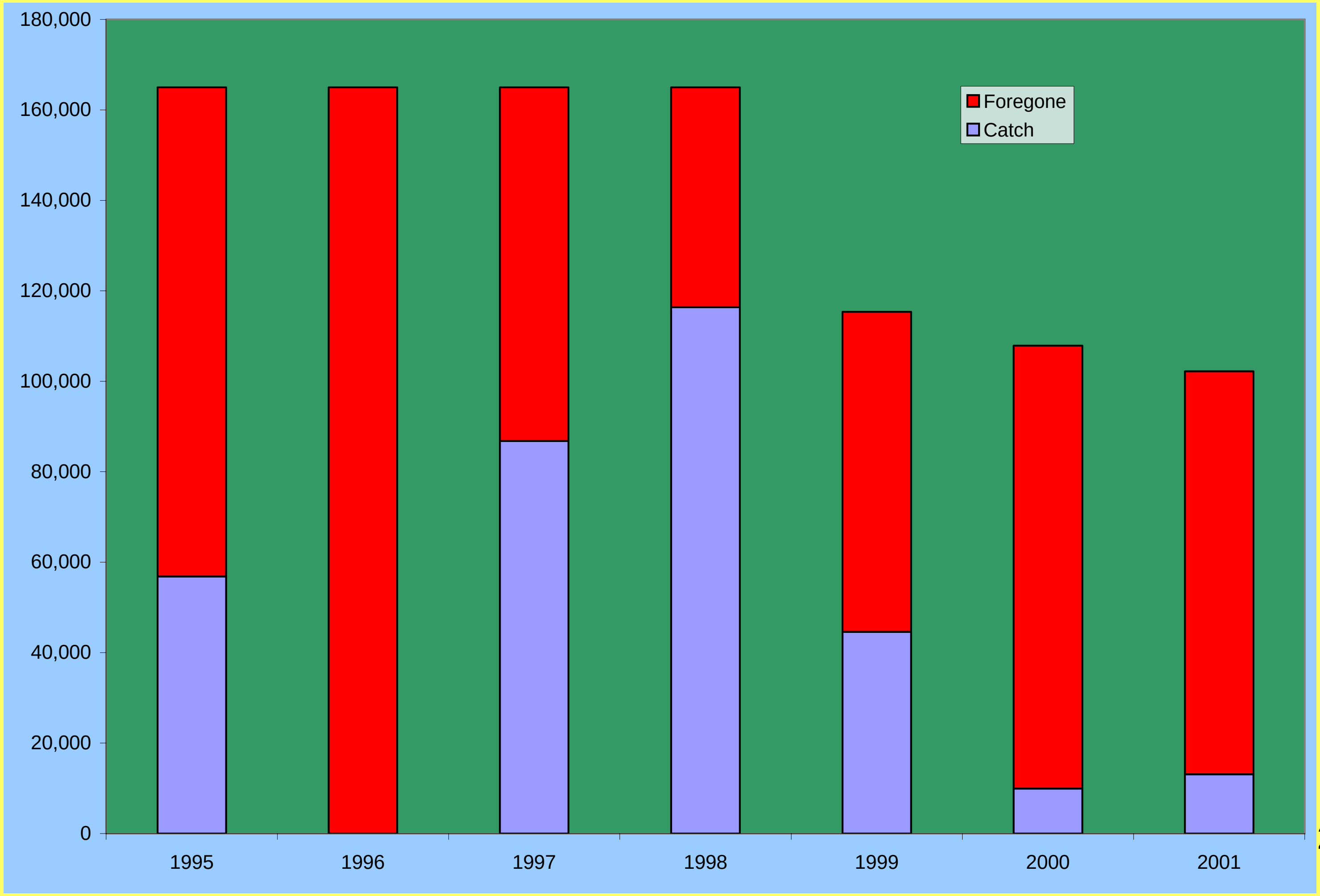
North Coast Troll: DNA for Chinook stock ID in-season

Winther, I., and Beacham, T.D. 2006. The application of Chinook salmon stock composition data to management of the Queen Charlotte Islands troll fishery, 2002 to 2005. Can. Tech. Rep. Fish. Aquat. Sci. 2665: vii + 88 p.



1995 – 2001: **Annual NBC Troll catch ranged between 0 and 70% of the allowable catch.**

On average only harvested 32% of the catch available within the PST allowance.



Objective of the 2002-2006 DNA program:

Allow the catch allocation under the 1999 PST Agreement to be harvested while minimizing impacts on WCVI Natural Chinook.

Concept:

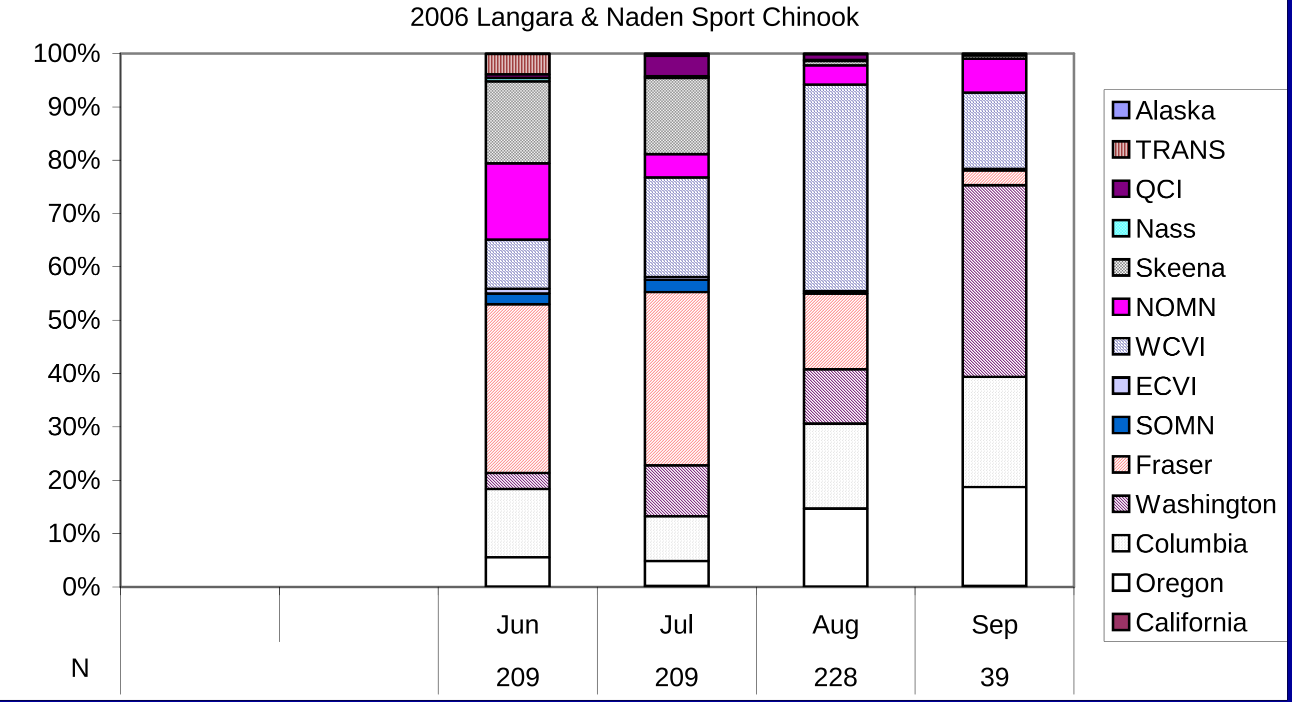
Shape fisheries around WCVI Chinook. Identify fishing sites, set up a standard sampling regime to establish trends in stock composition, and sample fisheries to identify catch composition.

2002 – 2006: NBC Troll Catch ranged between 64 and 103% of the preseason AABM catch available (minus the sport allocation)

On average harvested 92% of the catch available within the PST allowance.

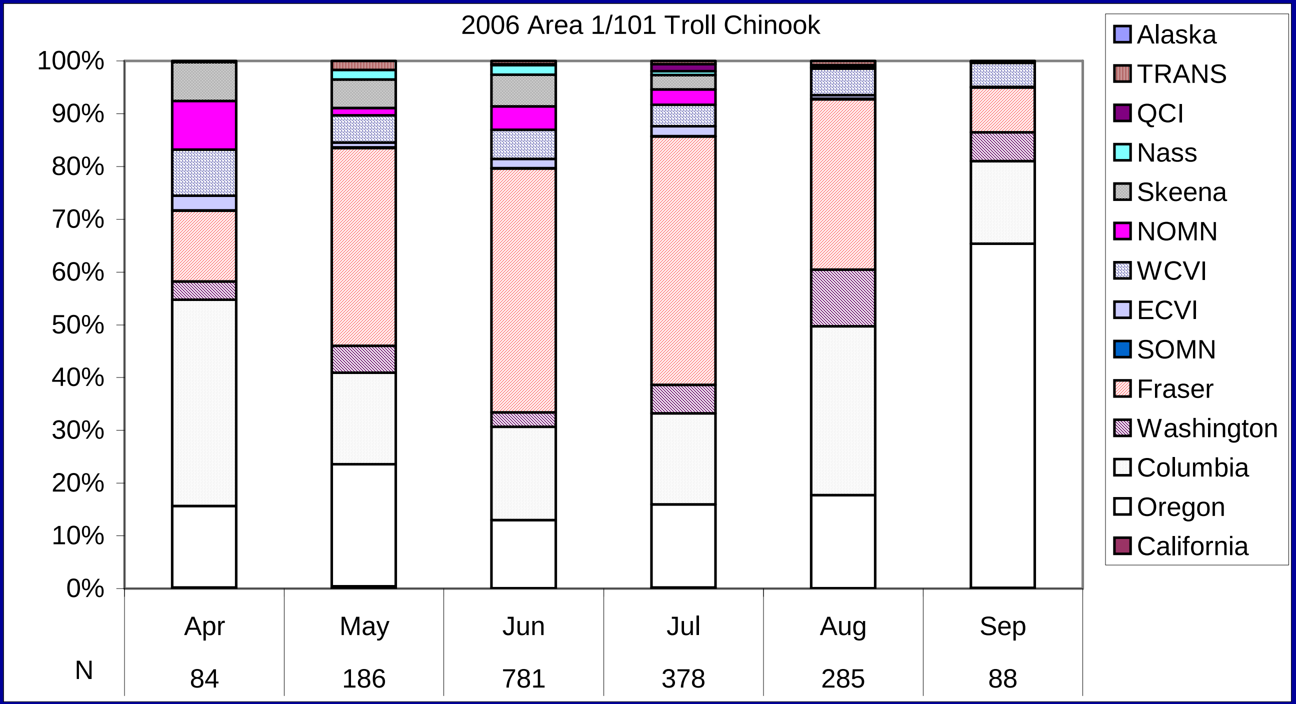
2006 QCI Sport

(Area 1/101)



2006 NBC troll

(Area 1/101)



Appendix 1. Management targets and actual catches for NBC troll fisheries from 2002 to 2006.

Year	AABM Preseason Ceiling	Total AABM Catch	QCI Sport Catch	Pre-season NBC Troll allocation	Post-season NBC Troll allowable catch	Actual NBC Troll Catch
2002	192,700	150,617	47,100	162,000	145,600	103,517
2003	197,067	191,657	54,300	152,000*	142,767	137,357
2004	243,640	241,508	74,000	183,640	169,640	167,508
2005	246,600	243,606	68,800	170,000	177,800	174,806
2006	223,200	222,838	64,500	153,200	158,700	158,363

* Revised in-season to 142,000

Year	Pre-season Troll target of WCVI Chinook (pieces)	Actual Troll catch of WCVI Chinook (pieces)	Pre-season Troll HR Target on WCVI Returns to Canada	Estimated Post-Season Troll HR on WCVI Return to Canada	Pre-season Target NBC Troll ER on WCVI	Estimated Post-season NBC Troll ER on WCVI Chinook
2002	3,052	6,811	1.6%	3.6%	1.5%	3.3%
2003	6,811	7,637	!	3.2%	!	2.7%
2004	7,800	10,065	3.6%	3.4%	3.3%	2.9%
2005	11,600	8,125	3.6%	4.1%	3.3%	3.5%
2006	6,344	6,465	3.2%	3.3%*	3.2%	2.9%

* preliminary 12 January 2007

Comparison of CWT and GSI

	CWT	GSI
Sample size reqmts	Coastwide standard guideline of at least 20% of catch. Specific requirements depend on statistic of interest, stock/fishery distribution patterns, tagging levels, stratification, sample rates, and level of uncertainty surrounding estimates of the size of the sampled population.	No standard sampling guideline. Specific sample size requirements depend on statistic of interest, *a priori* estimates of the proportion of the sampled population comprised of the stock of interest, the statistic of interest, genetic baseline employed, assignment error, uncertainty surrounding estimates of the size of the sampled population.

Absolute vs. Relative Error

ABSOLUTE ERROR

- **Independent of the magnitude of the estimate**

1% ± 5% = 0% to 6%

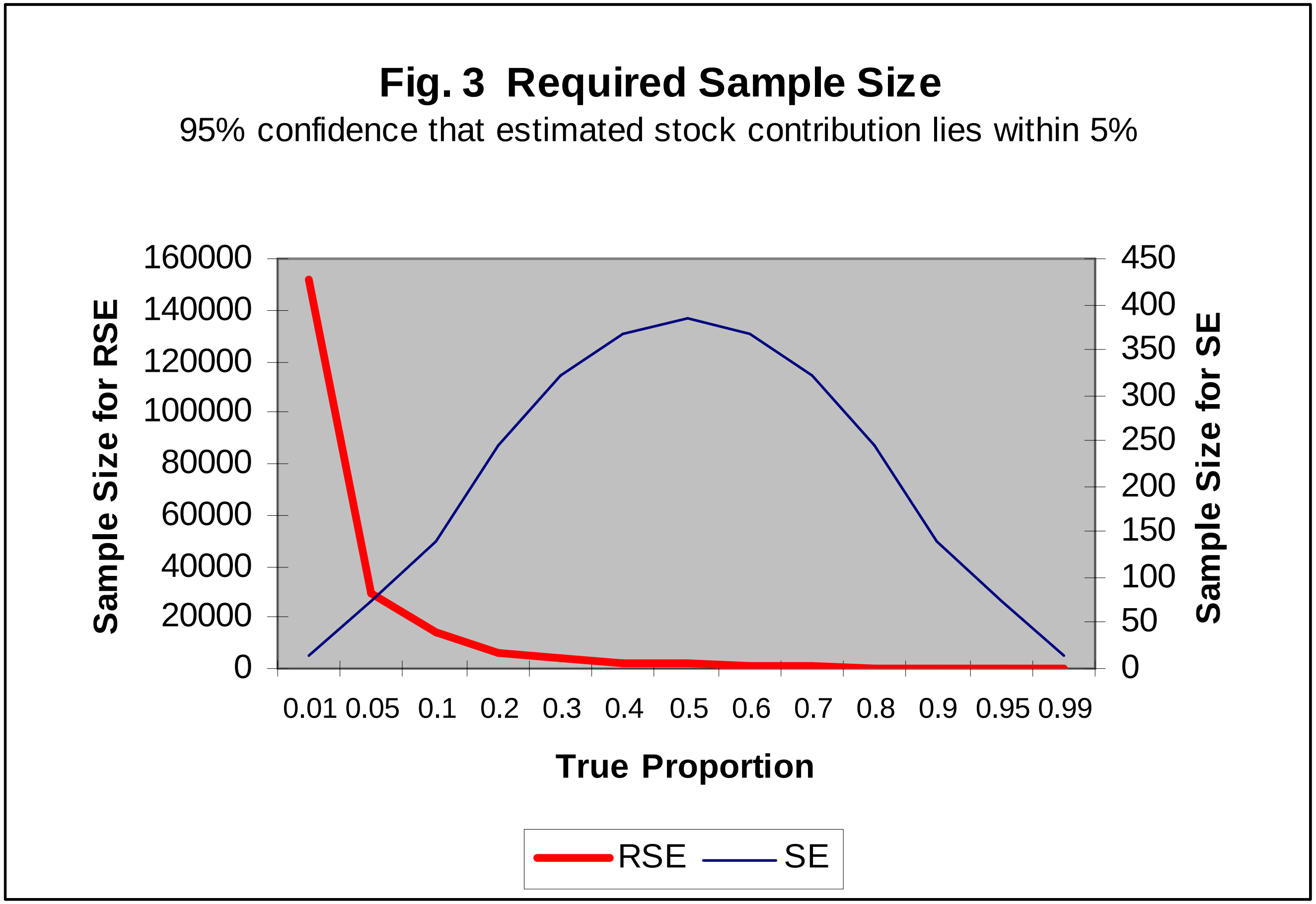
Not particularly useful for stocks comprising a small proportion of exploited population

RELATIVE ERROR

- **% of the estimate**

1% ± 5% = 0.95% to 1.05%

Sample Sizes & Prop'n To Estimate – Absolute v Relative Error



Comparison of CWT and GSI

	CWT	GSI
Signal amplification	Not dependent on relative proportion of the stock of interest in the sampled population	Depends on the proportion of the sampled population comprised of the group of interest and the DNA baseline employed

Comparison of CWT and GSI

	CWT	GSI
Data acquisition cost	Depends on the number of CWTs released, and recovered and processed (visual or ETD sampling to minimize cost)	All fish in sample must be processed; data extraction and analysis cost dependent on level of resolution required.

Example

	GSI	CWT
Total Catch	30000	30000
Sample Size	100	1000
Natural Stock A	89	890
CWT A	1	10
Natural Stock B	9	90
CWT B	1	10
Processing required	100	20

Comparison of CWT and GSI

	CWT	GSI
Representation of natural stock impacts	Hatchery stocks commonly employed as indicator stocks, based on brood stock, rearing & release strategy. Some stocks not represented (e.g., spring chinook)	Each fish carries its own genetic “tag”; representativeness depends on DNA baseline employed for analysis.

Complications From MSFs

- CWTs – DIT can provide some information
- GSI – What can be developed for GSI-based methods? DIT relies on differences in recovery rates between paired releases. With GSI, how can we estimate release sizes and recovery rates?

Questions:

1) What would be needed to obtain the required level of stock-age-group resolution using GSI?
   - ✓ Hatchery-Wild
   - ✓ Release strategies (yearling v. fingerling)
   - ✓ Stock assignment error
   - ✓ Aging error
2) What GSI sample sizes are required to accurately estimate contributions of stocks that comprise a small proportion of the exploited population?
3) How consistent and predictable are time/area patterns of encounters for stocks of interest?

Questions:

4) What would be required to collect and exchange the data required to perform cohort analyses using GSI?

5) How can GSI be used to improve our capacity to manage fisheries to achieve stock-specific objectives?

- Combine with CWTs to estimate escapements
- Estimate composition of non-landed mortalities
- In-season "shaping" of fisheries

6) How to address logistic needs and realities:

a) assurance of coast-wide cooperation with multiple agencies.

b) provision of capacity to process sample volumes

c) development of database management and access protocols.