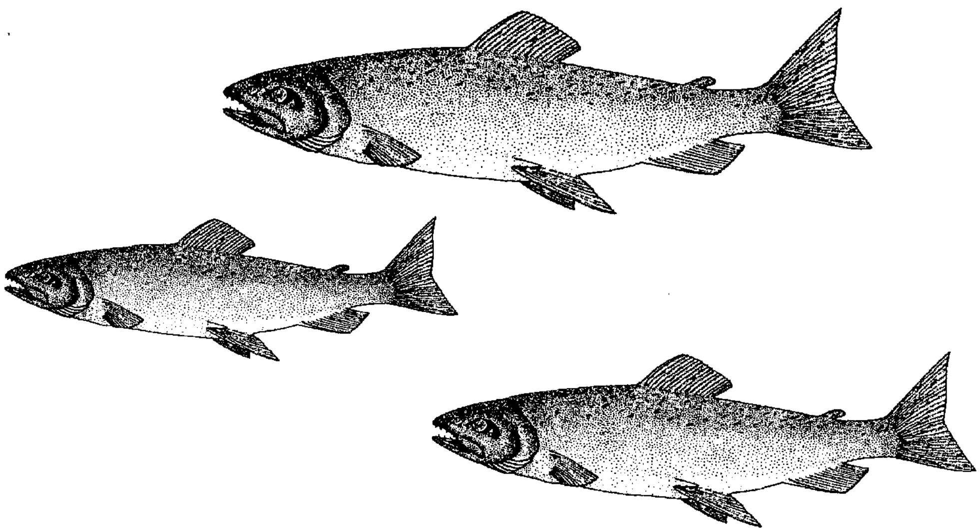
THE 1995-1998 FISHERY REGIME FOR SOUTHEAST ALASKA CHINOOK SALMON FISHERIES

By Jeffery P. Koenings, David Gaudet, Scott Marshall, and John E. Clark



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P.O. Box 25526
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Executive Summary

1995–1998 Fishery Regimes for Southeast Alaska Chinook Salmon Fisheries

This report describes a framework for a new abundance based fishery regime for chinook salmon in Southeast Alaska (SEAK). The regime is designed to actively constrain the total fishery harvest rate each year by allowing the catch to vary with observed overall abundance of chinook salmon stocks. This approach represents fundamental changes to chinook management in SEAK fisheries, and aligns chinook management with the inseason abundance managed salmon fisheries in SEAK.

Previous chinook salmon fishing regimes were developed around acceptable biological catches based upon long term forecasts of abundance. Potential impacts of fixed catches include, however, increased harvest rates and subsequent lower escapements. This new regime is specifically designed around actual inseason assessment of chinook salmon run strength using chinook catch per unit of effort (CPUE) of the core summer troll fishery, and will assure both conservation and fair sharing of harvestable chinook salmon.

In past years, the target fishery harvest rate was selected based upon the overall status of indicator stocks that contribute to the fishery and negotiation of social and economic factors among Commissioners of the Pacific Salmon Commission. At the time of this report, however, negotiations with Canada have not been completed for the 1995 fishing regimes or for the fishing regimes for the years 1996–1998 that are covered in this report. Absent modification by mutual agreement with Canada, the SEAK fishing regime described herein will be implemented for the 1995–1998 fisheries. Adjustment in harvest rates for the years 1996–1998 may be made, conditioned on such factors as stock status, but any such changes will not fall outside the rates examined in our biological assessment.

Estimated chinook abundance and a harvest rate index (1991–1993 average) resulted in a preseason target catch of 230,000 chinook salmon (excluding Alaska hatchery fish) in 1995 SEAK salmon fisheries.

Biological Assessment of Potential Impacts of SEAK Fisheries on Snake River Salmon

Clark et. al. (1995) contains a detailed assessment of the potential impacts of the 1995–1998 SEAK salmon fisheries on the ESA listed Snake River salmon. Neither Snake River sockeye salmon nor Snake River spring/summer chinook salmon are expected to be incidentally caught in SEAK salmon fisheries. Although ESA listed Snake River fall chinook salmon (SRFC) cannot be identified from other chinook salmon, small numbers of these fish are expected to be caught in SEAK salmon fisheries based upon past catches of coded-wire-tagged chinook from Lyons Ferry hatchery located in the State of Washington.

Analysis of potential relationships in prior years between the annual harvests (and rates of harvest) of SRFC in SEAK salmon fisheries and the overall chinook harvests, fishing efforts, and overall abundances of chinook in SEAK failed to reveal any useful relationships that could be reliably used to manage SEAK fisheries to minimize potential impacts of the SEAK salmon fisheries on SRFC. It was concluded that likely impacts of 1995-1998 SEAK salmon fisheries on SRFC would be in the range of impacts observed since 1979, the first year of available harvest and harvest rate estimates for these fish.

Population viability analyses were conducted where SEAK salmon fishery exploitation rates ranging from zero to historic high levels were simulated over 100 year periods to determine the likelihood of achieving threshold escapement levels of SRFC. Probabilities of achieving threshold escapements met the 70% National Marine Fishery Service (NMFS) jeopardy determination standard.

It was determined that although incidental catches of SRFC are likely to occur as a result of the 1995-1998 SEAK salmon fisheries, the continued existence of SRFC will not be jeopardized. Recommendations were made for issuance of a incidental take statement for SRFC in 1995-1998 SEAK salmon fisheries.

Cooperative Federal/State Fishery Management

The North Pacific Fishery Management Council (NPFMC) has deferred management of Alaska salmon fisheries to the State of Alaska. Under the April, 1990 Fishery Management Plan (FMP) for the Salmon Fisheries in the Exclusive Economic Zone (EEZ) off the coast of Alaska, the NPFMC "defers regulation of the commercial troll and recreational salmon fisheries in the EEZ to the ADF&G. The Director of the Alaska Region of NMFS reviews state management to assure consistency with the Salmon FMP, the Magnuson Fishery Conservation and Management Act (MFCMA) and the Pacific Salmon Treaty (PST). State of Alaska management regulations, limited entry licensing programs, reporting requirements, etc. are applied to the EEZ unless the "Director of the Alaska Region of the National Marine Fisheries Service. . .determines that he must issue a specific regulation for the salmon fisheries in the EEZ to ensure compliance with the FMP, MFCMA and PST."

The NPFMC, in the April 1995 meeting, deferred the consistency review of the 1995 SEAK fishery regime to the Director of the Alaska Region of the NMFS.

Overview

In general, the harvest rate imposed by a fishery is a function of the catch in the fishery and the aggregate abundance of the stocks within the fishery. During the 1994–1995 cycle of the Pacific Salmon Commission (PSC), preseason forecasts of abundance for the Robertson Creek hatchery (British Columbia, Canada) chinook stock indicated a brood year failure. These fish have contributed significantly to Southeast Alaska (SEAK) fisheries. A lower than average survival for some other chinook stocks was also projected. A concern was expressed that if SEAK fisheries harvested chinook at their historic ceiling of 263,000 that harvest rates on commingled chinook stocks would exceed those of recent years (1991–1993).

Alaska agreed, in principle, with restraining harvest rates to levels in recent years, however, the pessimistic forecasted abundance did not appear warranted based on both the observed bias in the PSC Chinook Technical Committee's (CTC) modeled preseason estimates and recent observed catch rates in the SEAK fishery. Alaska had serious questions over the shortcomings of the data used in both the PSC chinook salmon *abundance index* and *exploitation rate index*.

Herein, we explain the approach used by Alaska to establish an abundance based target catch[1] of 230,000 chinook salmon for SEAK fisheries that will result in achieving a fishery *harvest rate index* comparable to the 1991–1993 average *harvest rate index*[2]. Inseason estimates of chinook abundance projected form CPUE data will be used to adjust chinook catches to achieve the *harvest rate index*. Such inseason abundance based catches should result in both the conservation and fair sharing of chinook salmon.

Framework for Abundance Based Management of SEAK Chinook Fisheries

Estimating the Fishery Harvest Rate

In theory, the harvest rate imposed by a fishery is a function of the catch in a fishery and the abundance of the stocks. The SEAK chinook harvest rate is related to the catch for a given abundance as follows:

$$\mathrm{Ln}(HR_{yr}) = a + b_1\mathrm{Ln}(AI_{yr}) + b_2\mathrm{Ln}(C_{yr}) \qquad [1]$$

[1] The catch excludes Alaska's hatchery add-on of chinook salmon. The first 5,000 fish Alaska hatchery chinook salmon are counted in the base catch, the remainder are excluded.

[2] The harvest rate index is calculated using the landed catch from the troll fishery because of shortcomings in available data for net and sport fisheries.

Where

HR_{yr} = The target harvest rate for a given catch,
AI_{yr} = The abundance index for the year, and
C_{yr} = The troll catch.

Note: The all gear catch equals the troll catch divided by 0.81 plus 20,000, and the parameters used to estimate allowable chinook catches is detailed in Appendix B.

This basic notion provided the rationale for the chinook rebuilding program in which ceilings and pass-through provisions were adopted so as to increase spawning escapements (Figure 1). To examine this relationship, we computed a *catch index* for the troll fishery in Southeast Alaska by dividing the landed catch by the *abundance index* reported by the CTC and plotted this index against the CTC *exploitation rate index*. We were surprised by the relatively low R^2 value of 0.508 (Figure 2). We also examined relationships between the exploitation rate of the four main chinook stocks that comprise the CTC *exploitation rate index* and discovered trends in the individual stocks that were also difficult to explain by catch and abundance (Figure 3). The lack of clear relationships in these basic data lead us to question the accuracy of both the chinook *abundance index* and the *exploitation rate index* formulated by the CTC, since the only other variable, catch, is known with a high degree of accuracy.

We first examined the *abundance index* values computed each year by the CTC through the PSC Chinook Model (*see* Appendix A). We compiled *abundance index* estimates made during calibration of the chinook model each spring and fall for the years 1989–1995. For the SEAK fishery, these data show that the *abundance index* increases during each subsequent calibration for at least three or four years and that the average absolute change is about 0.6. Similar bias is evident in other fisheries (Figure 4 and Appendix A). These data demonstrate that the *abundance index* data from the model must be bias corrected for at least three and perhaps up to five years. If a bias correction of 0.6 is applied to the current calibration of the CTC model for the 1995 SEAK fishery, the estimated actual abundance will be 1.58 (0.6 + 0.98). This bias corrected abundance index is higher than the 0.98 *abundance index* derived for 1995 from the CTC model for SEAK.

Second, the *exploitation rate index* currently used by the CTC is constrained to stocks for which data are available during the "base period" years of 1979 to 1982. This severely limits the ability to measure impacts across the broader suite of stocks that contribute to the ceilinged fisheries that have had expensive tagging programs implemented since the base period. Besides artificially limiting the use of tagged stocks, we also questioned the appropriateness of the simple summation procedure currently used. After considering these issues, we developed an alternative *harvest rate index* (*see* Appendix B). We believe that this index represents a significant technical advance because it uses 57 stock/age combinations as opposed to the 13 stock/age combinations used by the CTC. When we regressed ADF&G's *catch index* against our new *harvest rate index*, the substantial improvement of fit (R^2 = 0.79) much more clearly demonstrated the connection between theory and practice in the rebuilding program. The average of this *harvest rate index* for the 1991-1993 period is 0.59 (compared to a higher average exploitation rate index of 0.61).

Figure 1. From "Technical Basis of Present Pacific Salmon Treaty Chinook Catch Ceilings". Presented at the PSC Chinook Workshop, January 10 and 11, 1991, Vancouver, B.C., Canada.

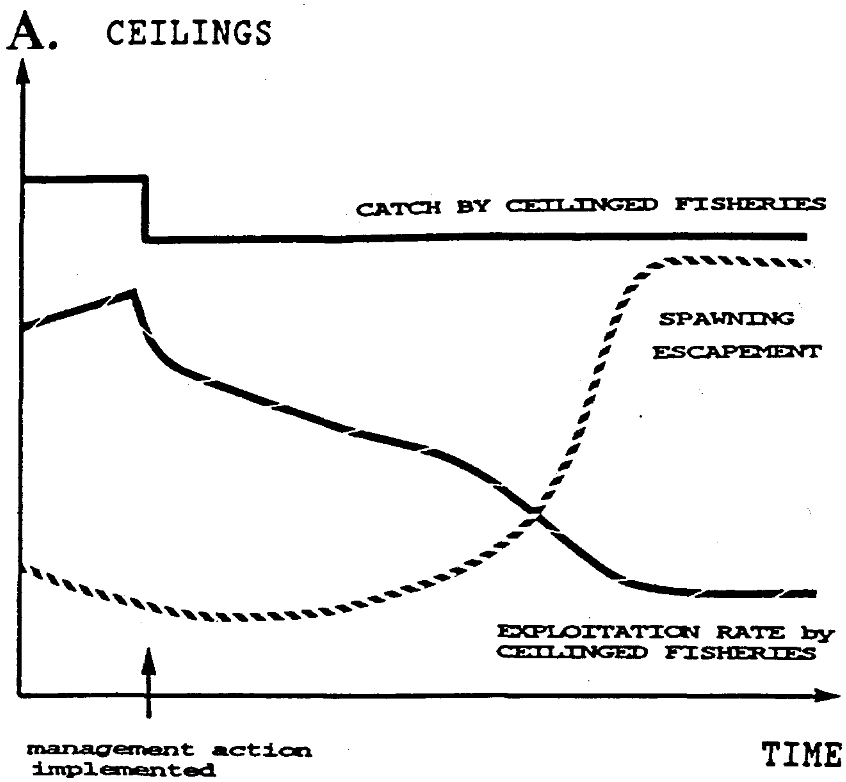


Figure 2. Relationship between the Catch Index and Exploitation Rate Index (Reported Catch Only) for the Southeast Alaska Troll Fishery.

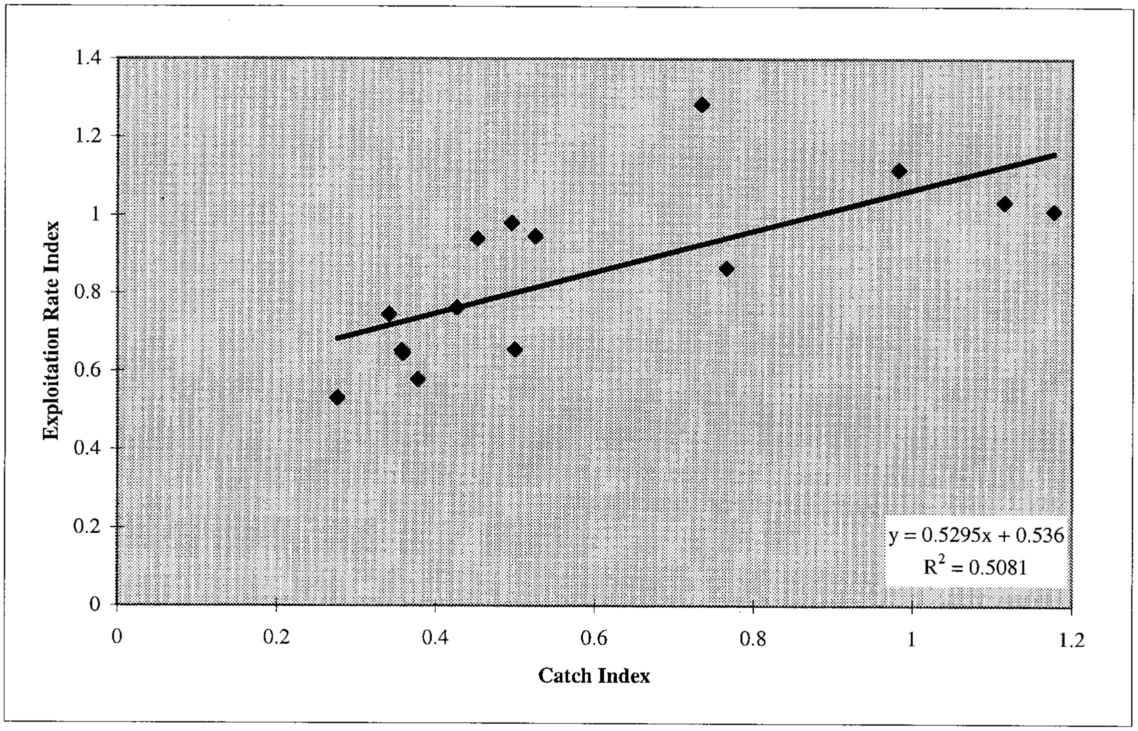


Figure 3. Exploitation rates of chinook stocks in the Southeast Alaska all-gear fishery.

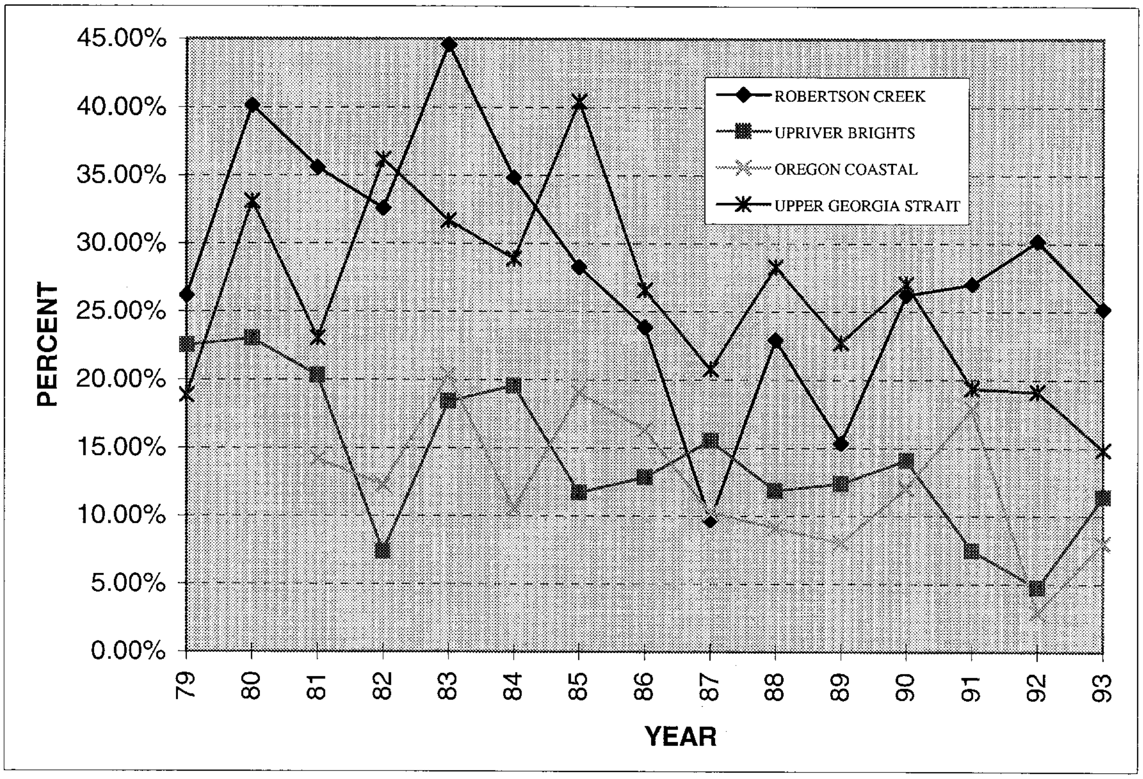
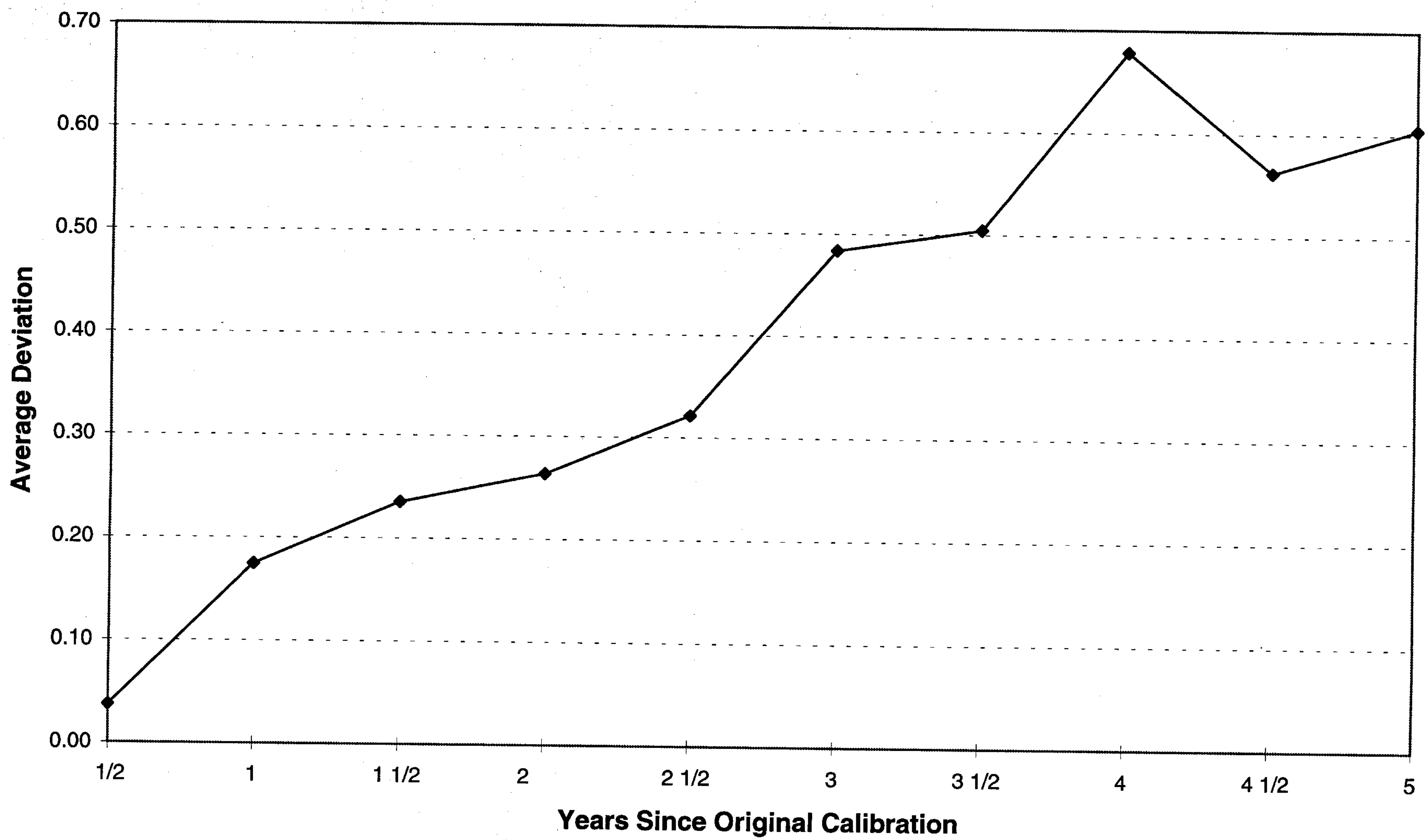


Figure 4. Average deviations in the Southeast Alaska Troll Abundance Index from the initial preseason projection.



ADF&G used this revised *harvest rate index* and the CTC post-season *abundance index*, after eliminating 1992–1995 because of recent year bias, in all of ADF&G's computations of the allowable chinook salmon harvest. Use of equation (1), an average 1991–1993 harvest rate, and the bias corrected abundance index would result in an allowable catch of 258,000 chinook salmon for 1995. A similar algorithm could be used to estimate allowable chinook salmon catches for the 1996–1998 SEAK fisheries.

Estimating Catch

Final catch data for SEAK commercial fisheries are compiled from fish tickets completed at the time of landing. However, for inseason management, SEAK commercial fisheries are monitored by methods specific to the type of fishery. Inseason methods provide samples of the fisheries and a rapid turnaround of data. Methods include dockside interviews with SEAK trollers to determine catch per unit of effort (CPUE) by specific area, vessel interviews with drift gillnetters to determine CPUE, overflights of all fisheries to determine effort by area, and tallies of tender landings for purse seine fisheries. SEAK recreational fisheries are monitored inseason by dockside creel census. After expansion to cover non-sampled fisheries, the creel census provides the inseason chinook catch estimate for managing the fishery. The final chinook catch for the sport fishery is not available until the following year when the statewide harvest mail-in survey is completed.

Salmon are sampled for coded wire tags (CWT) in all fisheries. An agreement between Pacific Coast States and Canada specifies a target sampling rate of at least 20%. Alaska commercial troll catches are typically sampled at 35–40%. For each sample, the following data are collected: port of landing, processor, date, vessel name and ADF&G number, statistical area and place name, gear type, number of fish inspected, number of fish with missing adipose fins, number of fish in delivery, and length of fish with adipose clips. Recovered CWTs are read at the ADF&G Mark/Tag laboratory in Juneau and information is reported to the Pacific States Marine Fisheries Commission CWT data center.

Chinook salmon catches in SEAK fisheries are known with a high degree of accuracy, and the use of coded wire tags provides a reasonable estimate of the harvest of appropriately tagged chinook salmon stocks.

Estimating Inseason Abundance

While CTC estimates of abundance in a fishery change significantly for three to four years, after that time, the estimates appear to stabilize. We reasoned that after three years, these estimates should be related to the CPUE observed in the SEAK troll fishery. We were particularly interested in determining if a relationship existed during the initial summer opening of the troll fishery that begins on July 1. An estimate of abundance made in July would allow us to make inseason adjustments to assure that the final season's catch in fact resulted in the desired *harvest rate index*. These estimates of CPUE were made using a "core fleet" (an approach used in other Southeast fisheries). The core fleet represents those fishermen who are most successful.

The relationship between CPUE during the first five days of the summer fishery was plotted against the CTC *abundance index* derived from the current calibration of the model for the years 1979 to 1991 (Figure 5). The years 1992 through 1995 were eliminated because of recent year bias in the CTC model. These data also show that accurate projections ($R^2 = 0.86$) of the CTC *abundance index* can be made from CPUE data. After the initial open period beginning July 1, we plan to make a projection of the CTC *abundance index*. This estimate, coupled with catch to date across all fisheries, provides a revised target catch for the remainder of the season.

Establishing a Fishery Harvest Rate and Resultant Target Catch

Non-Alaskan representatives within the PSC suggested that harvest rates for the SEAK fishery be restrained in 1995 to the level observed in recent years. Based on the CTC modeled projection of abundance of 0.98 for 1995, a drastic reduction in the level of catch was being advocated by some to constrain the harvest rate in SEAK fisheries. While agreeing in principle with the suggestion to restrain harvest rates to the level of recent years (e.g., 1991–1993 average), Alaska believed that the CTC forecasted chinook abundance for the SEAK fishery was overly pessimistic (based on the past observed bias in the modeled preseason estimates of abundance and recent observed catch rates in the fishery).

Through Alaska's inseason abundance assessment procedure, the actual chinook salmon catch can be adjusted to assure, if the actual abundance is either more or less than expected, that a fishery *harvest rate index* comparable to the period 1991–1993 will be achieved.

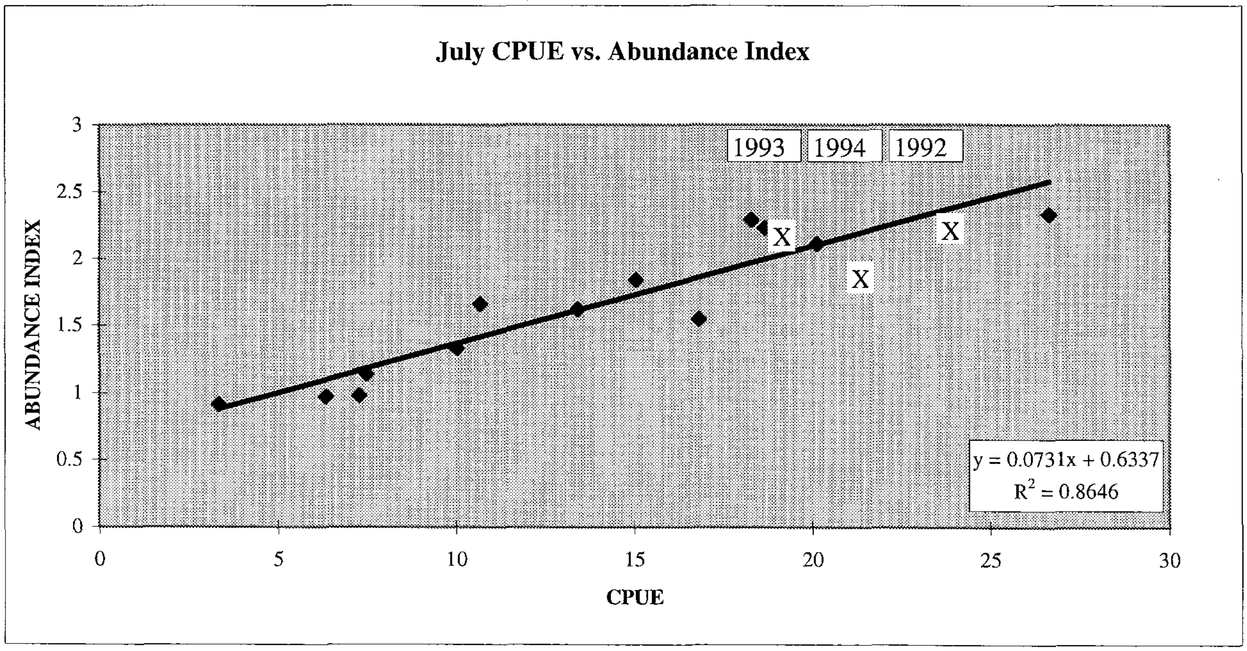
Because this is the first year management of the SEAK chinook fishery will be based on abundance so as to achieve a target harvest rate (1991–1993 average), we believe that a conservative approach to estimating preseason abundance is warranted. On the one hand, we could have either used the pessimistic CTC chinook model preseason *abundance index* of 0.98 for preseason planning (which results in a management target of 224,000 chinook) or we could have used the more optimistic bias corrected abundance index of 1.58 (which results in a target of 258,000 chinook). We chose a preseason planning abundance index of 1.08 (which results in a target of 230,000 chinook) that is above the CTC preseason *abundance index* (0.98) and is consistent with the higher CPUE estimated abundance (2.17) relative to the CTC modeled *abundance index* (1.98) over the recent 1992–1994 period (Figure 5). For 1995, changes to the preseason planning catch (230,000 treaty chinook), either upward or downward, requires a deviation in the inseason estimate of abundance from the preseason estimate of 1.08, based on the July CPUE data, greater than $\pm$ 0.2 (<0.88 or >1.28).

Recognizing the limitations of management to achieve a target catch, the PSC established a 7.5 percent management range for chinook fisheries under ceiling management. Management to achieve target harvest rates presents new technical and practical problems for monitoring compliance. In the short term especially, harvest rate data have not been available until the fall after the next summer fishing season. This means that it is impossible to make an adjustment to a fishery in one year based on the actual harvest rate the previous year. To address this problem, we believe the best approach is to monitor compliance as the deviation of actual catch from the allowable catch, where the allowable catch is based upon the July CPUE regression. We believe this is the appropriate measure for three reasons. First, it utilizes the best available

Figure 5. CPUE (catch per day) calculated on deliveries made during the first 5 days of fishing in July, up to the top 390 permits, 1979–1991 troll accounting years[1], versus the CTC Abundance Indices computed during calibration. Also shown are predicted and current CTC Abundance Indices for the years 1992–1994.

Year	No. Pemits	CPUE	ABUNDANCE INDEX
1979	390	7.2718	0.98
1980	390	6.3349	0.97
1981	390	3.3272	0.91
1982	390	7.4667	1.14
1983	390	10.0226	1.33
1984	122	13.4213	1.62
1985	390	16.8287	1.55
1986	390	10.6774	1.66
1987	390	15.0554	1.84
1988	390	18.2964	2.29
1989	390	20.1318	2.11
1990	390	18.6713	2.23
1991	390	26.6369	2.33

			------Abundance Index------	
		CPUE	Predicted from this model	CTC Estimate
1992	390	23.5882	2.36	2.13
1993	390	19.0021	2.02	2.13
1994	390	21.5964	2.12	1.67



[1] Southeast Alaska troll accounting years run from October 1 - September 30.

data to measure abundance at the time the fishery is prosecuted. Second, it measures compliance against the management target. Third, it permits use of the historic 7.5 percent procedure adopted by the PSC.

Management of Fisheries and Consistency with Alaska Board of Fisheries Regulations

The 1995 SEAK fishery will be specifically managed as follows:

> For 1995, SEAK fisheries will be managed for a target all-gear commercial and recreational harvest of 230,000 treaty chinook salmon. Changes in the targeted catch either upward or downward, would require a deviation in the preseason estimate of abundance, based on the July general summer fishery CPUE, of greater than $\pm$ 0.2 ($<$0.88 or $>$1.28).
>
> A 7.5% management range (based on 263,000) will apply in 1995. This limits the cumulative catch ceiling overages or underages since 1987 to 7.5% of the 263,000 base ceiling. If the cumulative overage exceeds the range (19,725 fish), it must be reduced in the following year to a level within the range. Underages below the 7.5% range can not be accumulated;
>
> An Alaska hatchery add-on will be calculated and the amount excluded from the base catch of 230,000.

Troll Fishery

The 1995 accounting year for chinook salmon for Southeast Alaska began with the opening of the winter troll fishery on October 11, 1994. The fishery continued through April 14. The fishery is estimated to have taken approximately 17,500 chinook salmon. Approximately 2,000 of these are estimated to have been from Alaskan hatcheries.

The troll fishery will remain closed until late May when terminal and near terminal (termed experimental) fisheries are conducted to target Alaskan hatchery chinook salmon. The total harvest in these fisheries is based on the percentage of the catch that is from Alaska hatcheries. As the percentage of the harvest from Alaska hatcheries increases, so does the over all number of fish allowed to be harvested. The number of non-Alaskan hatchery fish is limited depending upon the Alaskan hatchery percentage. All species of salmon are legal except that coho salmon cannot be retained until June 15. These fisheries continue until June 29.

The general summer all-species commercial troll fishery will begin July 1. The fishery will harvest the remainder of the chinook salmon available from the commercial troll allocation.

Beginning July 1, the fishery will be open to take approximately 70% of the allowable summer troll chinook salmon harvest. Following the first chinook salmon fishing period, the fishery will be closed to the harvest of chinook salmon. During this time, areas of frequent high chinook salmon abundance will be closed to all trolling, and in areas which remain open to the harvest of non-chinook salmon species, any chinook salmon incidentally hooked must be released. During this period, the fishery will be managed based on the abundance of coho salmon.

There are critical assessment times for coho salmon abundance. The first is at the end of July. If the total commercial catch of coho salmon is projected to be less than 1.12 million, then a seven day closure will be instituted beginning on or after July 25. The second assessment takes place in early August. At this time, ADF&G determines if it is necessary to close the commercial troll fishery for coho salmon in order to ensure movement of coho salmon into the inside areas of SEAK for either escapement or allocation to the inside fisheries. If a closure of the commercial troll fishery is necessary, it may occur for approximately 10 days. When the commercial troll fishery reopens, the fishery will be managed for both coho salmon and to harvest the remaining 30% of the allowable summer troll chinook salmon. If no closure is necessary, the commercial troll fishery will close for two days to allow for a clean start of the chinook salmon retention fishery. The areas of high chinook salmon abundance will be closed during these openings.

Purse Seine Fishery

The general purse seine fishery is managed primarily based on the abundance of pink salmon. Harvest of chinook salmon is incidental to the harvest of other species. Chinook salmon retention periods are established during weeks when high catch rates of non-chinook species occur, generally in early August. Thus, during chinook non-retention periods, the catches are generally low and chinook salmon are able to be sorted and released quicker. Only chinook salmon greater than 28 inches count against the quota. Chinook salmon between 21 and 28 inches may never be retained while those less than 21 inches may be retained and sold but do not count towards the quota. This regulation allows sorting of small chinook salmon caught incidentally from adult pink salmon.

Drift Gillnet Fishery

The drift gillnet fishery harvests chinook salmon incidentally to other species. Drift gillnet fisheries open on the third Sunday in June except for the Stikine District which will open on the second Sunday. These opening dates minimize the harvest of mature local chinook salmon stocks which are all spring type and are generally in river by late June. Night time closures are occasionally utilized to limit the incidental catch of treaty chinook. Terminal exclusions of Stikine and Taku chinook salmon may be implemented as larger numbers of these chinook salmon may be incidentally harvested due to large chinook returns and increased sockeye targeted effort to harvest anticipated large sockeye returns.

Set Gillnet Fishery

Set gillnet fisheries operate only in the Yakutat area where they are primarily limited to inriver fisheries. Chinook salmon are harvested incidentally in this fishery and management actions are based primarily upon sockeye returns. Chinook salmon stocks in these rivers are also all spring type and migration is through by late June.

Recreational Fishery

The recreational fishery will be managed to achieve the allocated harvest of Treaty chinook salmon. The fishery will be managed such that chinook salmon may be retained throughout the season. The department will use bag limits, gear restrictions and area closures to ensure that the harvest goal is not exceeded and that the fishery is spread throughout the season.

Management Measures to Minimize Harvest Impacts on ESA Listed Species

Significant management measures were taken prior to the 1994/1995 accounting period to reduce and minimize the incidental impacts of SEAK chinook fisheries on ESA listed salmon.

Winter Troll Fishery

Several measures were taken during the 1994/95 winter troll season to limit the catch compared to the historic fishery: 1) the fishery was closed October 1 through 10. This closure occurs during the time when catches are highest; 2) three coastal areas were closed to slow the catch rates; and 3) the total harvest was capped at 45,000 fish (including Alaska hatchery chinook salmon).

Spring Troll Fisheries

The June Hatchery Access fishery has been eliminated. This provided approximately 25,000 more fish for the summer troll fishery.

Summer Troll Fisheries

Six areas of frequent high chinook salmon abundance (Alaska Department of Fish and Game 1993) will be closed to all trolling during the second opening of the summer troll chinook season in mid August. The closure of these areas will reduce chinook catch rates and extend the closed during any chinook non-retention periods in order to reduce the number of encounters and thus the incidental mortality rate.

The above measures along with the expected lower aggregate chinook salmon in 1995 will reduce the incidental mortalities of all chinook salmon including the ESA listed Snake River fall chinook.

Literature Cited

Alaska Department of Fish and Game. 1993. Biological assessment of potential impacts on ESA listed Snake River salmon species by the 1993 salmon fisheries of Southeast Alaska.

Clark, J. H., J. E. Clark, D. Gaudet, and J. Carlile. 1995. Biological assessment of potential incidental impacts of 1995-1998 Southeast Alaska salmon fisheries on ESA listed Snake River salmon. Alaska Department of Fish and Game, Regional Information 1J95-15. 79 p.

Appendix A

Bias in the Modeled Abundances of Chinook Salmon

Methods

In order to quantitatively analyze the bias in the abundance indices, indices by year and by fishery were obtained from past calibrations (Appendix Table A1). Calibrations were selected for one postseason and one preseason. Post season calibrations were reported in recent CTC Annual Reports and often contained only recent catch information and did not contain age specific escapement or escapement data. The preseason calibration often would include these data. Years prior to 1989 cannot be used in the analysis since no preseason projections were made then.

Abundance indices estimates for each year were tabulated for each fishery (Appendix Tables A2 through A5) in the portion titled INDICES. For each year, the deviation from the initial estimate was tabulated in the portion of the table entitled DEVIATIONS. This was done for every half year until the estimate from the last calibration (February 1995). For 1990, there were a total of 10 observations of the amount the abundance index increased from the initial estimate. The mean and standard deviation were calculated, and the maximum and minimum observations were made for the deviations by time after the initial estimate.

Results

For Southeast Alaska, the average deviation from the initial estimate to the final estimate increases by 0.60 (Appendix Table A2, Appendix Figure A1). It appears that 3 to 4 years are required for the estimate to stabilize.

For North Central BC, the results are similar to Southeast Alaska with the final estimate being from 0.60 to 0.70 greater than the initial estimate (Appendix Table A3, Appendix Figure A2). Like that for the Southeast Alaska Troll, it appears to takes approximately 3 to 4 years to stabilize.

For WCVI troll, the average deviation from the initial estimate to the final approximately 0.35 is smaller than for either Southeast Alaska or NCBC (Appendix Table A4, Appendix Figure A3). The time for stabilization is slightly longer than for the northern fisheries, approximately 4 to 5 years.

The pattern for Georgia Strait Troll and Sport is similar to that of WCVI. The average deviation from the initial estimate to the final estimate is 0.55 (Appendix Table A5, Appendix Figure A4). Also like WCVI, it takes approximately 4 to 5 years to stabilize.

The residuals were also plotted for the relations (Appendix Figure A5). The residuals show that for the plot with data through 1994, the 1994 data point, the one currently furthest out, is furthest from the line as expected. The 1992 and 1991 points are also currently below the line. Only the 1993 data point is above the line.

Appendix Table A1. Data sources for the Chinook Abundance Indices.

1989	Calibration from November, 1989
1990A	Calibration #790, February, 1990
1990B	Calibration #990, November, 1990
1991A	Calibration #491, February,1991
1991B	None
1992A	Calibration #921, May, 1992
1992B	Calibration #9226, February, 1993
1993A	Calibration #9324, May, 1993
1993B	Calibration #93AC, October, 1993
1994A	Calibration #9408, February 1994
1994B	Calibration #1094P, October 1994
1995	Calibration #9521, February 1995

Appendix Table A2. Southeast Alaska Troll Abundance Indices, 1979 to 1995.

YEAR	1989	1990A	1990B	1991A	1991B	1992A	1992B	1993A	1993B	1994A	1994B	1995
1979	1.02	1.02	1.02	1.03	NA	1.03	0.99	0.99	0.97	0.98	0.98	0.98
1980	1.00	1.00	1.00	1.00	NA	1.00	0.97	0.97	0.95	0.97	0.96	0.97
1981	0.96	0.96	0.96	0.96	NA	0.97	0.95	0.95	0.93	0.91	0.91	0.91
1982	1.01	1.03	1.02	1.01	NA	1.01	1.09	1.09	1.15	1.13	1.15	1.14
1983	1.10	1.07	1.06	0.99	NA	0.96	1.28	1.28	1.37	1.40	1.38	1.33
1984	1.29	1.22	1.27	1.26	NA	1.23	1.56	1.56	1.53	1.72	1.70	1.62
1985	1.68	1.71	1.72	1.66	NA	1.63	1.48	1.48	1.48	1.63	1.60	1.55
1986	1.37	1.38	1.39	1.38	NA	1.35	1.57	1.57	1.59	1.70	1.66	1.66
1987	1.60	1.61	1.68	1.60	NA	1.59	1.83	1.84	1.85	1.87	1.84	1.84
1988	1.93	1.88	1.96	1.96	NA	1.96	2.32	2.33	2.27	2.35	2.30	2.29
1989	1.67	1.79	1.90	1.86	NA	1.87	1.95	1.96	1.97	2.12	2.05	2.11
1990		1.63	1.77	1.78	NA	1.70	1.96	1.97	1.96	2.23	2.19	2.23
1991			2.01	1.58	NA	1.66	1.82	1.79	1.81	2.24	2.26	2.33
1992					NA	1.67	1.63	1.77	1.76	1.93	2.08	2.13
1993							1.44	1.61	1.65	1.92	1.99	2.13
1994									1.26	1.43	1.44	1.67
1995											1.00	0.98

INDICES

	SPRING	YEARS AFTER											
YEAR	BEFORE	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1989	NA	1.67	1.79	1.90	1.86	NA	1.87	1.95	1.96	1.97	2.12	2.05	2.11
1990	1.63	1.77	1.78	NA	1.70	1.96	1.97	1.96	2.23	2.19	2.23		
1991	1.58	NA	1.66	1.82	1.79	1.81	2.24	2.26	2.33				
1992	1.67	1.63	1.77	1.76	1.93	2.08	2.13						
1993	1.61	1.65	1.92	1.99	2.13								
1994	1.43	1.44	1.67										
1995	0.98												

DEVIATIONS

	SPRING	YEARS AFTER											
YEAR	BEFORE	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	1.63	0.14	0.15	NA	0.08	0.33	0.34	0.33	0.61	0.56	0.60		
1991	1.58	NA	0.08	0.24	0.21	0.23	0.66	0.68	0.75				
1992	1.67	-0.04	0.09	0.09	0.25	0.40	0.45						
1993	1.61	0.04	0.32	0.39	0.52								
1994	1.43	0.00	0.23										
1995	0.98												

	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
MEAN	0.04	0.17	0.24	0.26	0.32	0.48	0.50	0.68	0.56	0.60	NA	NA
STD DEV.	0.08	0.10	0.15	0.19	0.09	0.16	0.24	0.10	NA	NA	NA	NA
MAX	0.14	0.32	0.39	0.52	0.40	0.66	0.68	0.75	0.56	0.60	NA	NA
MIN	-0.04	0.08	0.09	0.08	0.23	0.34	0.33	0.61	0.56	0.60	NA	NA
# OF OBS	4	5	3	4	3	3	2	2	1	1	0	0

Appendix Table A3. North Central BC Troll Abundance Indices, 1979 to 1995.

	1989	1990A	1990B	1991A	1991B	1992A	1992B	1993A	1993B	1994A	1994B	1995
1979	1.03	1.02	1.02	1.03	NA	1.04	1.01	1.01	1.01	1.02	1.02	1.02
1980	0.98	0.97	0.98	0.99	NA	0.99	0.97	0.97	0.96	0.96	0.96	0.97
1981	0.96	0.96	0.97	0.98	NA	0.98	0.94	0.94	0.94	0.93	0.93	0.94
1982	1.03	1.05	1.03	1.00	NA	0.99	1.08	1.08	1.09	1.09	1.09	1.08
1983	0.96	0.89	0.91	0.89	NA	0.88	1.14	1.14	1.19	1.17	1.16	1.13
1984	1.39	1.40	1.41	1.41	NA	1.35	1.32	1.32	1.26	1.37	1.37	1.34
1985	1.05	1.12	1.12	1.18	NA	1.16	1.18	1.18	1.23	1.31	1.30	1.28
1986	1.03	1.06	1.06	1.09	NA	1.07	1.20	1.20	1.16	1.26	1.24	1.24
1987	0.93	0.98	1.01	1.01	NA	1.00	1.07	1.08	1.38	1.44	1.42	1.42
1988	0.98	1.10	1.14	1.15	NA	1.16	1.22	1.21	1.51	1.56	1.54	1.55
1989	0.92	1.07	1.12	1.11	NA	1.11	1.11	1.12	1.48	1.60	1.57	1.60
1990		0.98	1.10	1.06	NA	1.05	1.07	1.07	1.40	1.61	1.60	1.63
1991			1.17	0.97	NA	1.04	1.02	1.03	1.33	1.51	1.53	1.56
1992					NA	1.02	0.94	1.03	1.37	1.41	1.49	1.52
1993							0.97	1.09	1.26	1.35	1.36	1.46
1994									1.09	1.06	1.04	1.00
1995											0.94	0.86

INDICES

	SPRING	YEARS AFTER											
YEAR	BEFORE	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1989	NA	0.92	1.07	1.12	1.11	NA	1.11	1.11	1.12	1.48	1.60	1.57	1.60
1990	0.98	1.10	1.06	NA	1.05	1.07	1.07	1.40	1.61	1.60	1.63		
1991	0.97	NA	1.04	1.02	1.03	1.33	1.51	1.53	1.56				
1992	1.02	0.94	1.03	1.37	1.41	1.49	1.52						
1993	1.09	1.26	1.35	1.36	1.46								
1994	1.06	1.04	1.00										
1995	0.86												

DEVIATIONS

	SPRING	YEARS AFTER											
YEAR	BEFORE	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	0.98	0.12	0.07	NA	0.07	0.09	0.09	0.42	0.63	0.62	0.65		
1991	0.97	NA	0.07	0.05	0.06	0.36	0.54	0.56	0.59				
1992	1.02	-0.07	0.01	0.35	0.39	0.47	0.50						
1993	1.09	0.17	0.27	0.28	0.37								
1994	1.06	-0.02	-0.06										
1995	0.86												
	MEAN	0.05	0.07	0.23	0.22	0.31	0.38	0.49	0.61	0.62	0.65	NA	NA
	STD DEV.	0.12	0.12	0.16	0.19	0.20	0.25	0.10	0.03	NA	NA	NA	NA
	MAX	0.17	0.27	0.35	0.39	0.47	0.54	0.56	0.63	0.62	0.65	NA	NA
	MIN	-0.07	-0.06	0.05	0.06	0.09	0.09	0.42	0.59	0.62	0.65	NA	NA
	# OF OBS	4	5	3	4	3	3	2	2	1	1	0	0

Appendix Table A4. WCVI Troll Abundance Indices, 1979 to 1995.

YEAR	1989	1990A	1990B	1991A	1991B	1992A	1992B	1993A	1993B	1994A	1994B	1995
1979	1.00	1.01	0.99	0.99	NA	0.99	1.02	1.02	1.02	1.04	1.03	1.04
1980	0.95	0.95	0.93	0.94	NA	0.94	0.97	0.97	0.97	1.00	1.00	1.00
1981	0.91	0.91	0.90	0.90	NA	0.90	0.93	0.93	0.93	0.95	0.95	0.95
1982	1.15	1.12	1.18	1.17	NA	1.16	1.09	1.09	1.08	1.02	1.02	1.02
1983	0.82	0.77	0.76	0.74	NA	0.73	0.95	0.95	0.97	0.83	0.83	0.83
1984	1.12	1.01	1.03	1.05	NA	1.01	0.94	0.94	0.96	0.94	0.94	0.94
1985	0.78	0.78	0.79	0.92	NA	0.91	0.92	0.93	0.94	0.95	0.94	0.94
1986	0.95	0.92	0.89	1.04	NA	1.01	0.96	0.97	0.99	0.95	0.95	0.95
1987	0.93	0.92	0.91	0.94	NA	0.92	0.94	0.88	1.24	1.15	1.15	1.14
1988	0.77	0.78	0.80	0.80	NA	0.81	0.77	0.74	1.05	0.95	0.95	0.94
1989	0.56	0.56	0.63	0.64	NA	0.62	0.63	0.64	0.90	0.92	0.91	0.92
1990		0.56	0.62	0.60	NA	0.66	0.61	0.63	0.88	0.92	0.92	0.92
1991			0.68	0.60	NA	0.53	0.51	0.52	0.73	0.75	0.73	0.74
1992					NA	0.60	0.56	0.57	0.82	0.78	0.72	0.75
1993							0.59	0.72	0.83	0.75	0.69	0.70
1994									0.84	0.70	0.67	0.54
1995											0.66	0.55

INDICES

	SPRING	YEARS AFTER											
YEAR	BEFORE	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1989	NA	0.56	0.56	0.63	0.64	NA	0.62	0.63	0.64	0.90	0.92	0.91	0.92
1990	0.56	0.62	0.60	NA	0.66	0.61	0.63	0.88	0.92	0.92	0.92		
1991	0.60	NA	0.53	0.51	0.52	0.73	0.75	0.73	0.74				
1992	0.60	0.56	0.57	0.82	0.78	0.72	0.75						
1993	0.72	0.83	0.75	0.69	0.70								
1994	0.70	0.67	0.54										
1995	0.55												

DEVIATIONS

	SPRING	YEARS AFTER											
YEAR	BEFORE	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	0.56	0.06	0.04	NA	0.10	0.05	0.06	0.32	0.35	0.35	0.36		
1991	0.60	NA	-0.07	-0.09	-0.08	0.13	0.14	0.13	0.14				
1992	0.60	-0.04	-0.03	0.22	0.18	0.12	0.15						
1993	0.72	0.11	0.03	-0.04	-0.03								
1994	0.70	-0.03	-0.16										
1995	0.55												

	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
MEAN	0.02	-0.04	0.03	0.04	0.10	0.12	0.22	0.25	0.35	0.36	NA	NA
STD DEV.	0.07	0.08	0.17	0.12	0.04	0.05	0.13	0.15	NA	NA	NA	NA
MAX	0.11	0.04	0.22	0.18	0.13	0.15	0.32	0.35	0.35	0.36	NA	NA
MIN	-0.04	-0.16	-0.09	-0.08	0.05	0.06	0.13	0.14	0.35	0.36	NA	NA
# OF OBS	4	5	3	4	3	3	2	2	1	1	0	0

Appendix Table A5. Georgia Strait Troll and Sport Abundance Indices, 1979 to 1994.

YEAR	1989	1990A	1990B	1991A	1991B	1992A	1992B	1993A	1993B	1994A	1994B	1995
1979	NA	1.15	1.15	1.15	NA	1.16	1.17	1.17	1.13	1.17	1.17	1.17
1980	NA	1.04	1.05	1.06	NA	1.06	1.07	1.07	1.03	1.03	1.03	1.03
1981	NA	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.96	0.94	0.94	0.94
1982	NA	0.81	0.80	0.79	NA	0.79	0.77	0.77	0.88	0.86	0.86	0.86
1983	NA	0.79	0.79	0.77	NA	0.75	0.75	0.75	0.90	0.79	0.79	0.83
1984	NA	0.73	0.75	0.81	NA	0.79	0.82	0.82	1.00	0.96	0.96	1.03
1985	NA	0.49	0.51	0.73	NA	0.73	0.80	0.81	0.90	0.96	0.97	0.97
1986	NA	0.37	0.35	0.59	NA	0.58	0.57	0.57	0.69	0.85	0.85	0.86
1987	NA	0.35	0.35	0.42	NA	0.43	0.38	0.39	0.48	0.49	0.49	0.49
1988	NA	0.33	0.34	0.34	NA	0.34	0.36	0.36	0.54	0.44	0.44	0.43
1989	NA	0.24	0.28	0.28	NA	0.30	0.33	0.34	0.73	0.65	0.65	0.65
1990		0.30	0.37	0.38	NA	0.41	0.43	0.44	0.71	0.84	0.84	0.84
1991			0.31	0.37	NA	0.38	0.30	0.30	0.67	0.54	0.52	0.53
1992					NA	0.35	0.41	0.41	0.83	0.72	0.63	0.64
1993							0.43	0.63	0.95	0.72	0.64	0.58
1994									0.96	0.92	0.85	0.53
1995											0.97	0.65

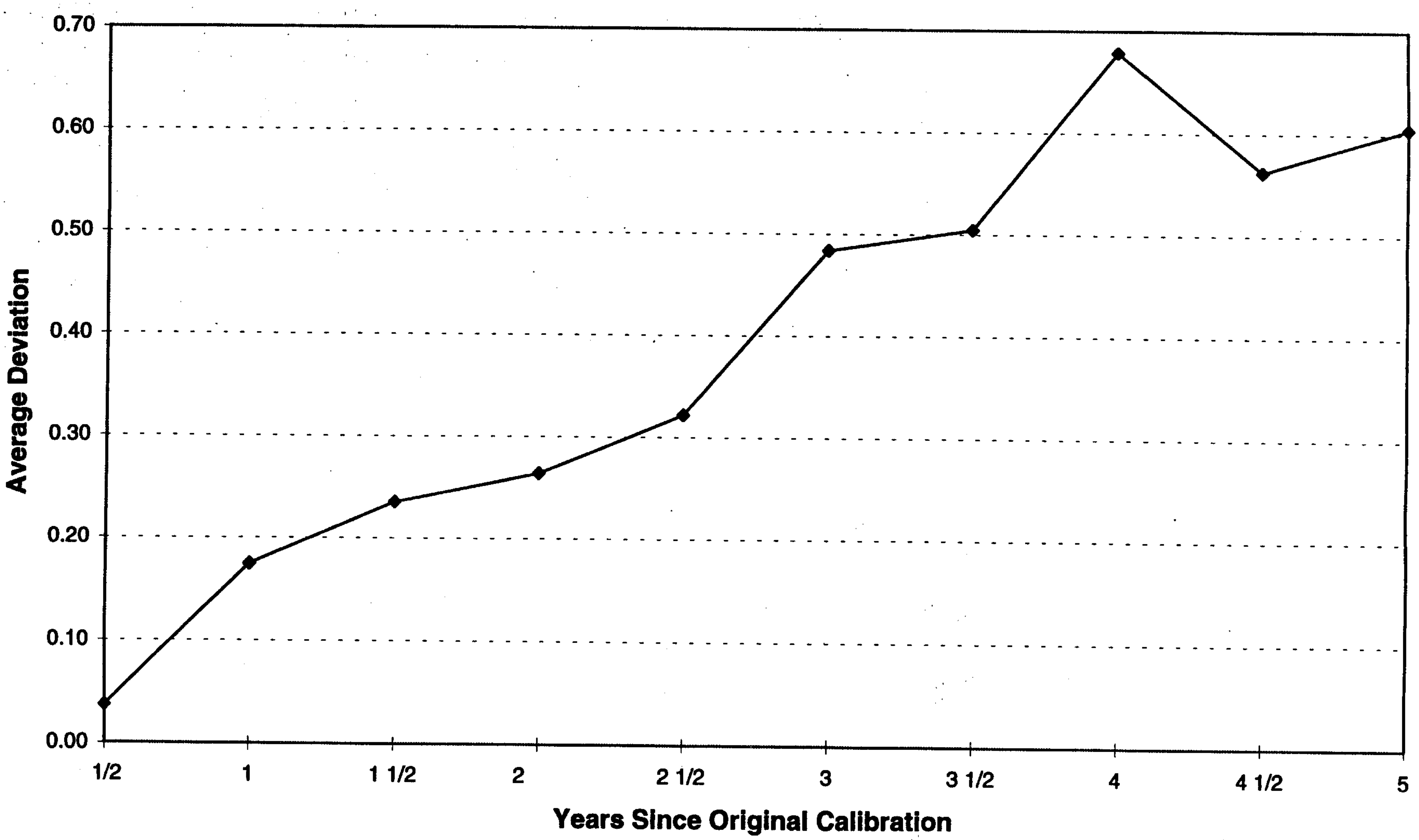
INDICES

	SPRING	YEARS AFTER											
YEAR	BEFORE	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1989	NA	NA	0.24	0.28	0.28	NA	0.30	0.33	0.34	0.73	0.65	0.65	0.65
1990	0.30	0.37	0.38	NA	0.41	0.43	0.44	0.71	0.84	0.84	0.84		
1991	0.37	NA	0.38	0.30	0.30	0.67	0.54	0.52	0.53				
1992	0.35	0.41	0.41	0.83	0.72	0.63	0.64						
1993	0.63	0.95	0.72	0.64	0.58								
1994	0.92	0.85	0.53										
1995	0.65												

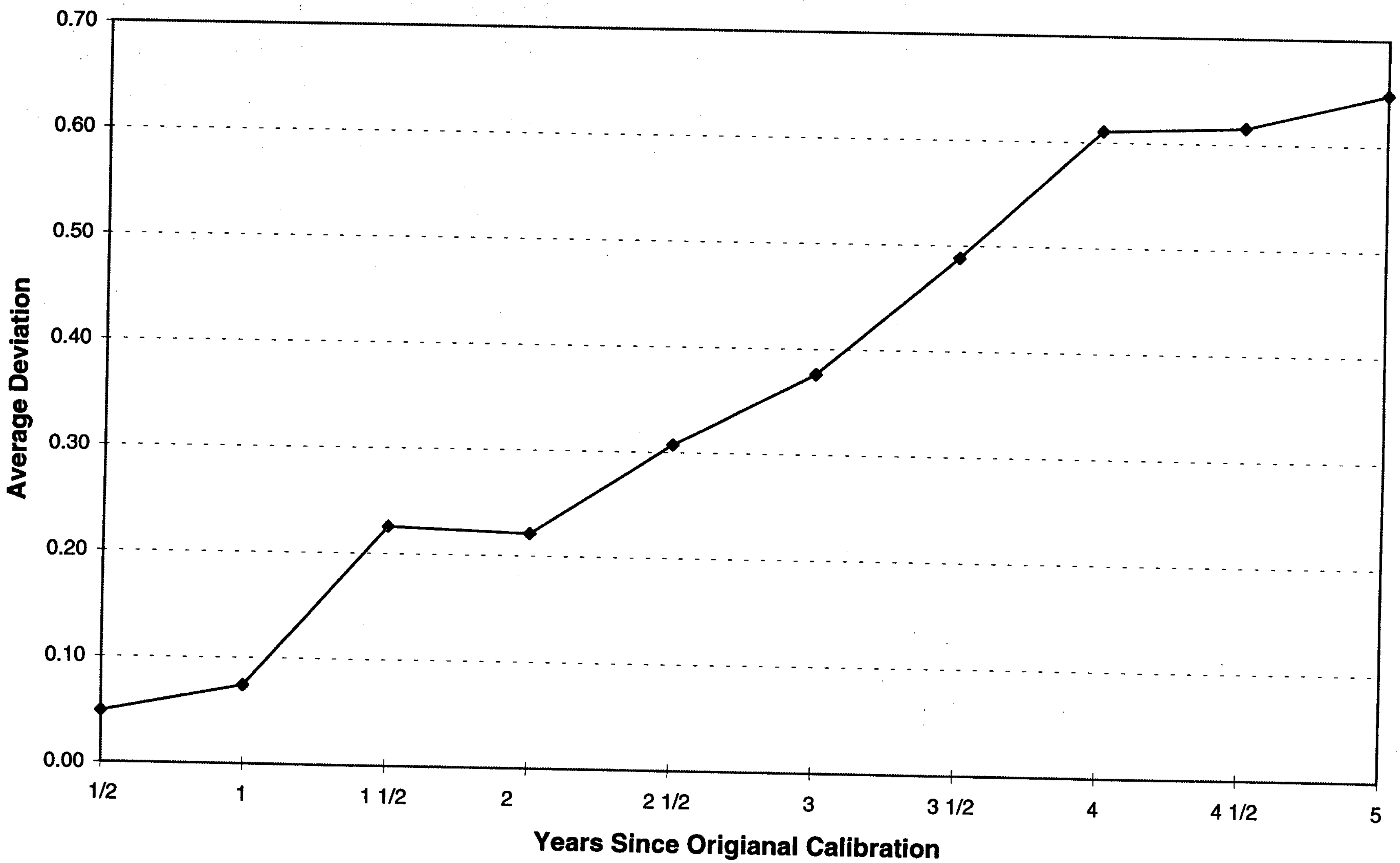
DEVIATIONS

	SPRING	YEARS AFTER											
YEAR	BEFORE	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	0.30	0.07	0.08	NA	0.11	0.13	0.14	0.41	0.54	0.54	0.54		
1991	0.37	NA	0.01	-0.07	-0.07	0.30	0.17	0.15	0.16				
1992	0.35	0.07	0.06	0.48	0.38	0.28	0.30						
1993	0.63	0.32	0.09	0.01	-0.05								
1994	0.92	-0.07	-0.39										
1995	0.65												
	MEAN	0.10	-0.03	0.14	0.09	0.24	0.20	0.28	0.35	0.54	0.54	NA	NA
	STD DEV.	0.16	0.20	0.30	0.21	0.09	0.08	0.19	0.27	NA	NA	NA	NA
	MAX	0.32	0.09	0.48	0.38	0.30	0.30	0.41	0.54	0.54	0.54	NA	NA
	MIN	-0.07	-0.39	-0.07	-0.07	0.13	0.14	0.15	0.16	0.54	0.54	NA	NA
	# OF OBS	4	5	3	4	3	3	2	2	1	1	0	0

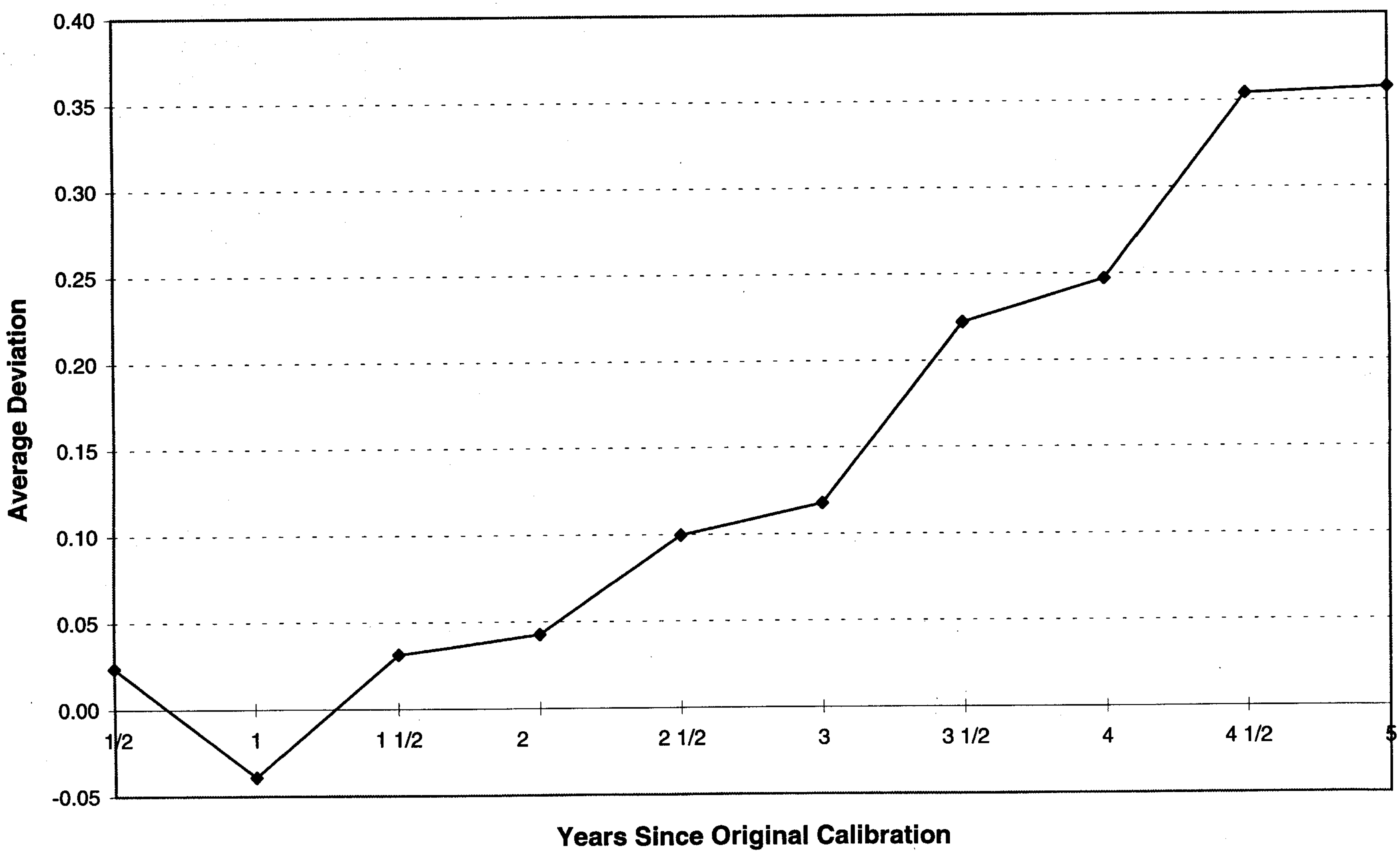
Appendix Figure A1. Average deviations in the Southeast Alaska Troll Abundance Index from the initial preseason projection.



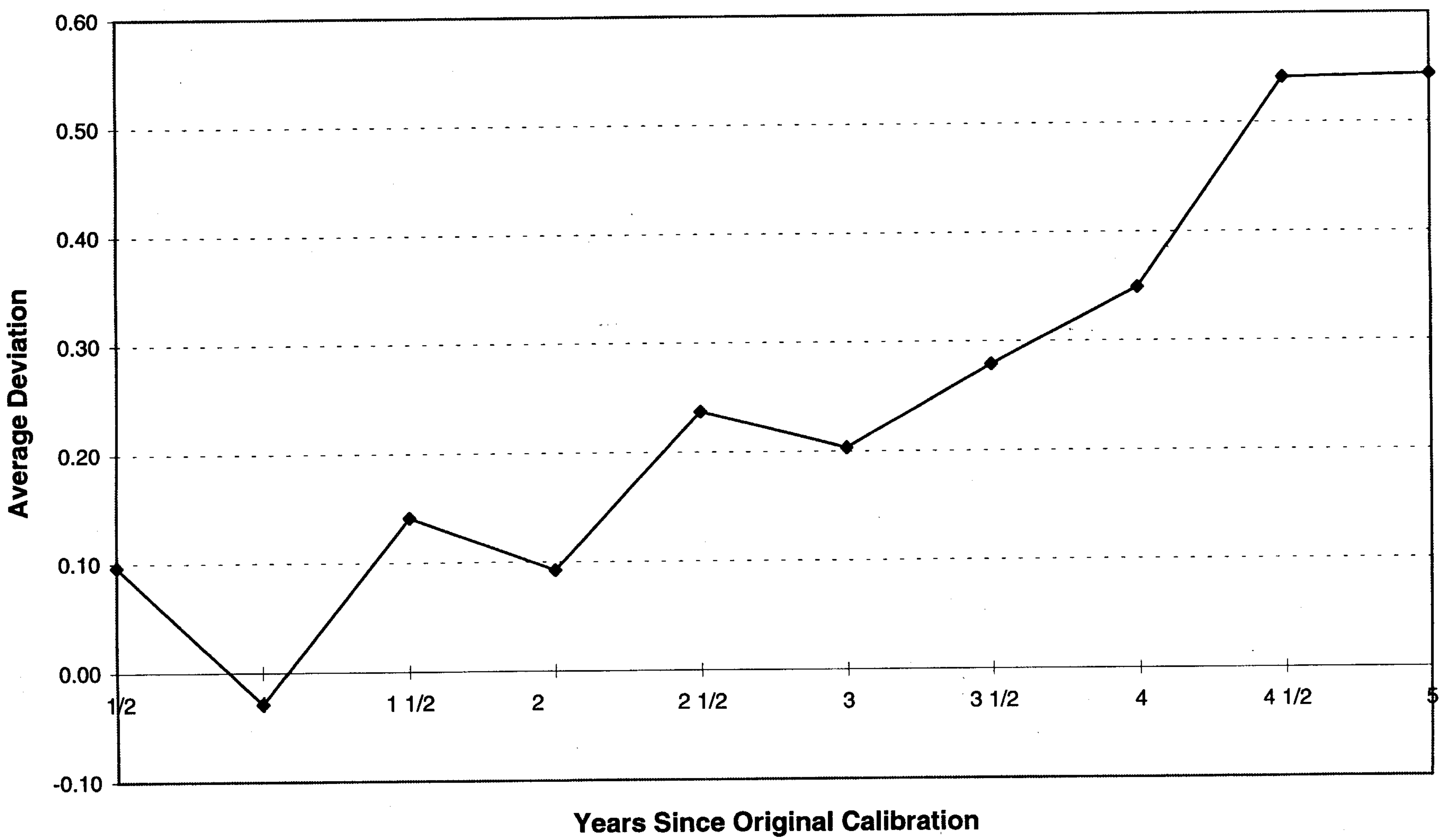
Appendix Figure A2. Average deviations in the North Central B.C. Troll Abundance Index from the initial preseason projection.



Appendix Figure A3. Average deviations in the WCVI Troll Abundance Index from the initial preseason projection.

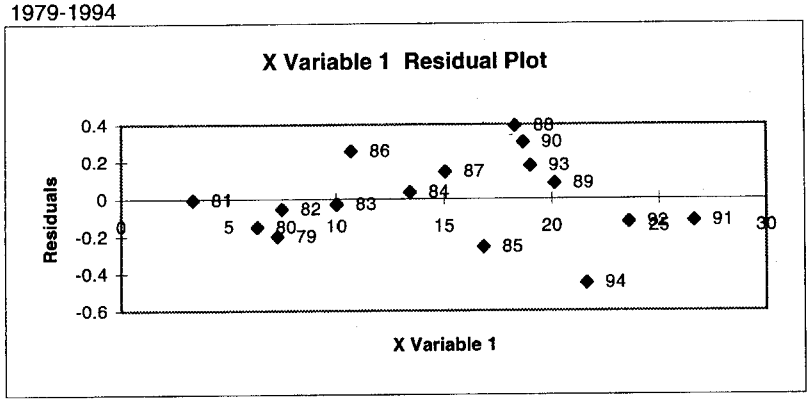


Appendix Figure A4. Average deviations in the Georgia Strait Sport and Troll Abundance Index from the initial preseason projection.

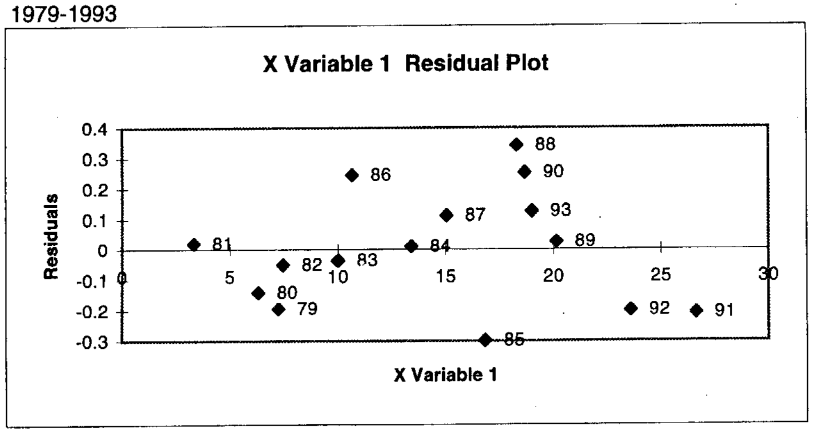


Appendix Figure A5. Residual plots for regression of the CTC Abundance Index using calibration #9521 versus the July troll CPUE.

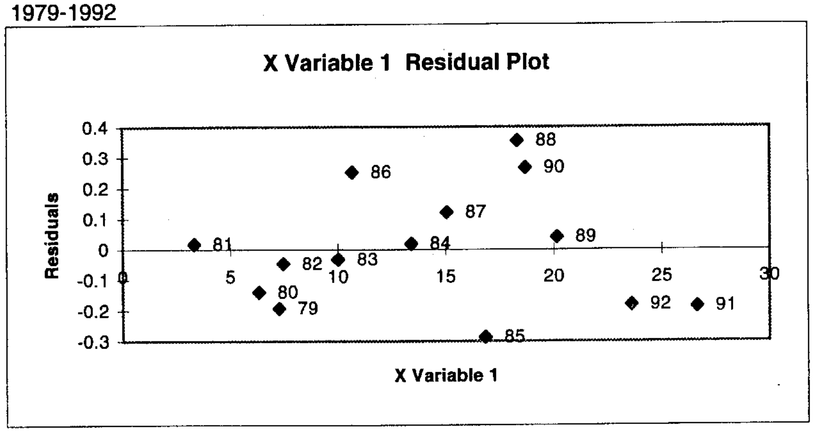
1979-1994



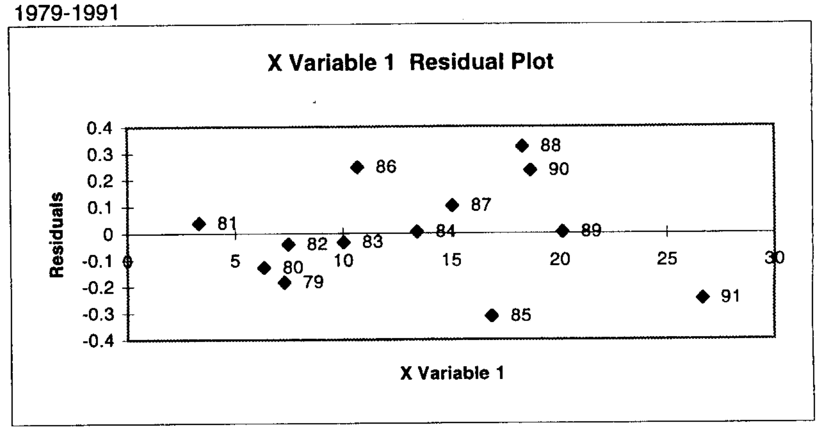
1979-1993



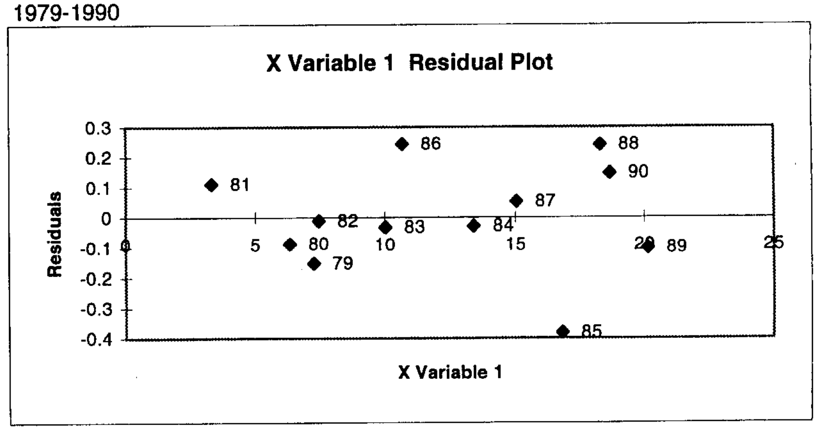
1979-1992



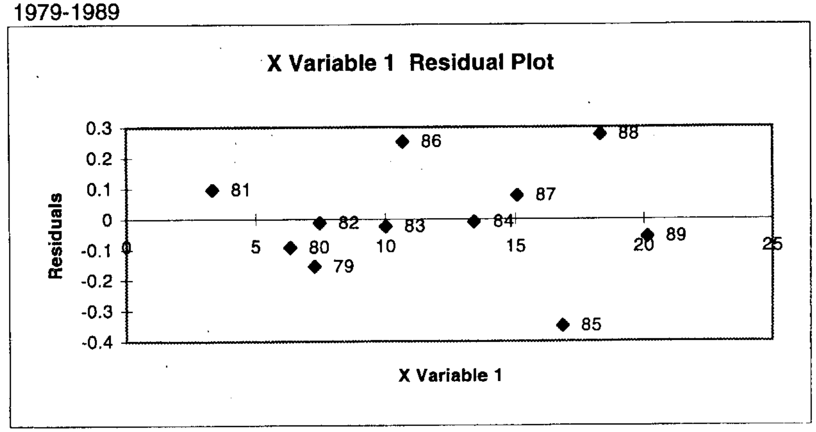
1979-1991



1979-1990



1979-1989



Appendix B

Theory and Calculation of the ADF&G Harvest Rate Index

Theory

A new approach to estimating relative harvest rates in the ceilinged fisheries is proposed by ADF&G. This approach provides a more representative assessment of trends in harvest rates. It is also somewhat self-weighting, thus removing the necessity to exclude stocks and ages where small number of tags were recovered. This approach also provides a means to include stocks and ages whose first CWT recoveries occurred after the base period. It also provides smoother year to year changes in trends and is more consistent with catch and abundance data. For the following discussion, the new index is called a *harvest rate index*, as opposed to the current *exploitation rate index* calculated by the CTC.

The approach can be illustrated with a simple example. Let's say that there are three stock/age (s/a) groups of coded wire tagged fish in our fishery which are being used to monitor the harvest rate in the fishery. The abundance of the s/a's in the fishery is designated as $A_{s/a}$ where s/a is 1, 2, or 3. Let's say that $A_1 = 2{,}000$, $A_2 = 200$, and $A_3 = 1{,}000$ tagged fish (which, of course, is seldom known unless the fishery is a terminal type of fishery). The harvest is sampled for CWTs and the number of CWTs harvested by the fishery is estimated (denoted as $T_{s/a}$). This results in an estimated 195 tags from A_1 being harvested ($T_1 = 195$ tags), 23 tags from A_2 being harvested ($T_2 = 23$ tags), and 102 tags from A_3 being harvested ($T_3 = 102$ tags). The best (most precise) estimate of harvest rate in this fishery is $(T_1+T_2+T_3)$ divided by (A_1+A2+A_3) or 320/3200 = 0.10.

For the ceilinged fisheries, estimates of the number of fish or tags available for harvest in the fishery is not known. However, estimates of the total abundance of a given s/a is available from the cohort analysis. Thus if the proportion of a s/a that is available to a fishery (termed $p_{s/a}$) is known or able to be estimated, and the cohort size for a given age and brood year is known or estimated for a given year (yr) of catch (termed $C_{s/a,\,yr}$), an estimate of harvest rate in a given year (HR_{yr}) is still possible:

$$p_{s/a} = \frac{\sum_{yr} T_{s/a,\,yr}}{\sum_{yr} HR_{yr}\, C_{s/a,\,yr}} \qquad [1]$$

where the $p_{s/a}\, C_{s/a,\,yr}$ are an estimate of the $A_{s/a,\,yr}$.

A system of equations and observations can be formulated to estimate the $p_{s/a}$'s and the HR_{yr} by year and s/a. If the $p_{s/a}$'s are assumed to be consistent from year to year, and the harvest rates apply equally across the s/a's for a given year, then the HR_{yr}'s and $p_{s/a}$'s can be iteratively estimated with the set of equations for harvest rate by year (Equation 1) and

$$HR_{yr} = \frac{\sum_{s/a} T_{s/a,\,yr}}{\sum_{s/a} p_{s/a}\, C_{s/a,\,yr}} \qquad [2]$$

Note that to get a unique set of values for HR_{yr} and $p_{s/a}$, at least 1 $p_{s/a}$ needs to be set to some value. This is because for any set of HR_{yr} and $p_{s/a}$, the HR_{yr}'s can be multiplied by a constant and the $p_{s/a}$'s by the inverse of that constant to yield the same results. However, the relative magnitude of the HR's and $p_{s/a}$'s will be the same (i.e. index value) independent of the value chosen for 1 of the $p_{s/a}$s. Thus with the data provided by the cohort analysis, we can estimate an index of harvest rates, but true harvest rates can only be estimated if we know at least 1 $p_{s/a}$ (and probably many more for a reliable absolute estimate of the harvest rates).

The $p_{s/a}$'s can also be considered as a weighting factor. If all stocks and ages are completely or equally vulnerable to a fishery, then they should be harvested in proportion to their abundance (as estimated by the cohort analysis). If this were the case, then the best estimate of a harvest rate would be the total number of tags harvested divided by the sum of the tagged cohort sizes for each age and stock. This obviously isn't the case, since proportionally more older age fish and more fish of certain stocks (i.e., Robertson Creek releases compared to Columbian River Tule stocks in the Alaskan fisheries) are harvested in certain fisheries, compared to other stocks and ages vulnerable in the fishery. The proposed method is a way of weighting the ages and stocks that are more vulnerable in a fishery.

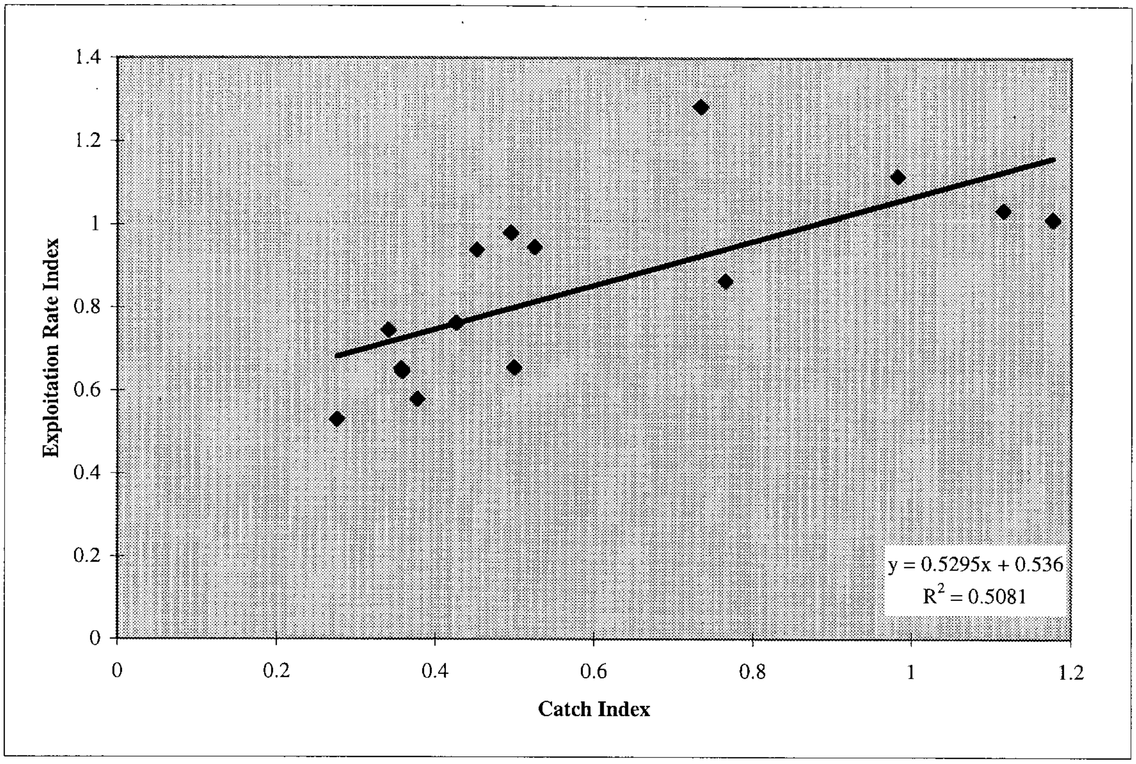
Harvest rate indices were calculated for each of the 4 ceilinged fisheries. Data were obtained from the stock and brood year specific output files from the harvest rate analysis (i.e. AKS88CBY.OUT). Depending on the type of data in the file, abundances were calculated as the cohort size expressed as a percent of the total release times the total release and times the appropriate natural mortality, or as the actual number of tags times natural mortality. Catches were obtained from the ceiling files (CLB9501.CEI) for the Alaska troll catch and from CTC CTCHINOOK (94)-1 the other three ceiling fisheries.

Results

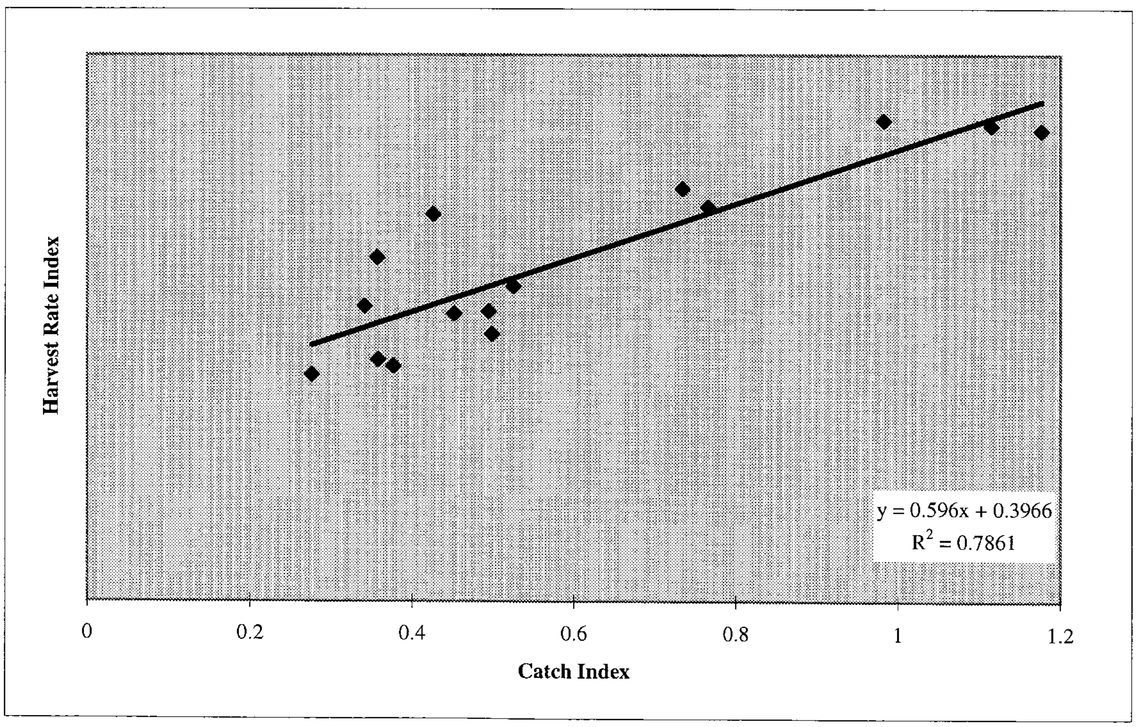
The *harvest rate index* appears to be a better relative measure of change in harvest rates in the ceiling fisheries than the CTC *exploitation rate index*. One comparison that was conducted was to look at the relationship between a *catch index* and the *harvest rate* and *exploitation rate indices*. The *catch index* is defined as the observed catch for a fishery and year (less add-on for the Alaska troll fishery) divided by the corresponding abundance index. It is transformed into an index by dividing this quantity through by the 1979–1982 average values. The catch index should be closely related to the harvest and exploitation rate indices, since for a given abundance index, larger or smaller catches should directly correspond to larger or smaller harvest and exploitation rate indices respectively, and for a given catch, larger or smaller abundances should directly correspond to smaller or larger harvest and exploitation rate indices respectively. Appendix Figures B1 and 2 compare the relation between these various indices and Appendix Tables B1–4 provide estimates of all of the indices. The harvest rate indices were better fitted to catch indices, as indicated by the much higher R^2 value (0.786 compared to 0.508 for exploitation rate indices) (Appendix Table B1). Improvement in R^2 values was found for the other 3 ceiling fisheries as well (0.918 compared to 0.699 for the North/Central troll fishery, 0.756 compared to 0.677 for the West Coast of Vancouver Island Troll fishery, and 0.585 compared to 0.514 for the Georgia Strait sport and troll fisheries).

The annual comparison of harvest rate indices, exploitation rate indices, and catch indices are shown in Appendix Figures B3-6. The year to year trend in harvest rate indices are much more consistent (i.e. the line tends to be smoother) than exploitation rate indices. Although many more stock and age combinations are used to calculate the harvest rate indices (57 combinations for Alaska troll fishery

Appendix Figure B1. Relationship between the Catch Index and Exploitation Rate Index (Reported Catch Only) for the Southeast Alaska Troll Fishery.



Appendix Figure B2. Relationship between the Catch Index and Harvest Rate Index (Reported Catch Only) for the Southeast Alaska Troll Fishery.



Appendix Table B1. Comparison of the *harvest rate index* with the *exploitation rate index* for the SEAK troll fishery.

Catch Year	Abundance Index	Harvest Index	Exploitation Rate Index	Troll Catch	Catch Index
1979	0.98	1.034	1.011	320,000	1.177
1980	0.97	1.044	1.033	300,000	1.115
1981	0.91	1.056	1.116	248,000	0.982
1982	1.14	0.866	0.864	242,000	0.765
1983	1.33	0.906	1.284	271,000	0.734
1984	1.62	0.691	0.945	236,000	0.525
1985	1.55	0.636	0.980	212,827	0.495
1986	1.66	0.586	0.655	229,980	0.499
1987	1.84	0.631	0.939	230,901	0.452
1988	2.29	0.647	0.745	216,427	0.341
1989	2.11	0.515	0.579	220,966	0.377
1990	2.23	0.850	0.762	263,340	0.426
1991	2.33	0.754	0.652	230,712	0.357
1992	2.13	0.496	0.531	162,995	0.276
1993	2.13	0.529	0.645	211,590	0.358

Appendix Table B2. Comparison of the *harvest rate index* with the *exploitation rate index* for North/Central B.C. troll fishery.

Catch Year	Abundance Index	Harvest Index	Exploitation Rate Index	Troll Catch	Catch Index
1979	1.01	1.117	0.975	244,706	1.019
1980	0.97	1.018	1.123	249,675	1.083
1981	0.94	1.056	1.163	218,699	0.979
1982	1.08	0.809	0.739	237,536	0.925
1983	1.13	0.986	0.941	253,688	0.945
1984	1.34	0.714	0.966	254,157	0.798
1985	1.28	0.575	0.870	211,979	0.697
1986	1.24	0.621	0.770	201,604	0.684
1987	1.42	0.612	0.727	239,693	0.710
1988	1.55	0.416	0.441	181,907	0.494
1989	1.6	0.394	0.603	224,947	0.597
1990	1.63	0.415	0.670	179,130	0.462
1991	1.56	0.303	0.703	220,625	0.595
1992	1.52	0.267	0.678	181,851	0.503
1993	1.46	0.322	0.742	182,162	0.525

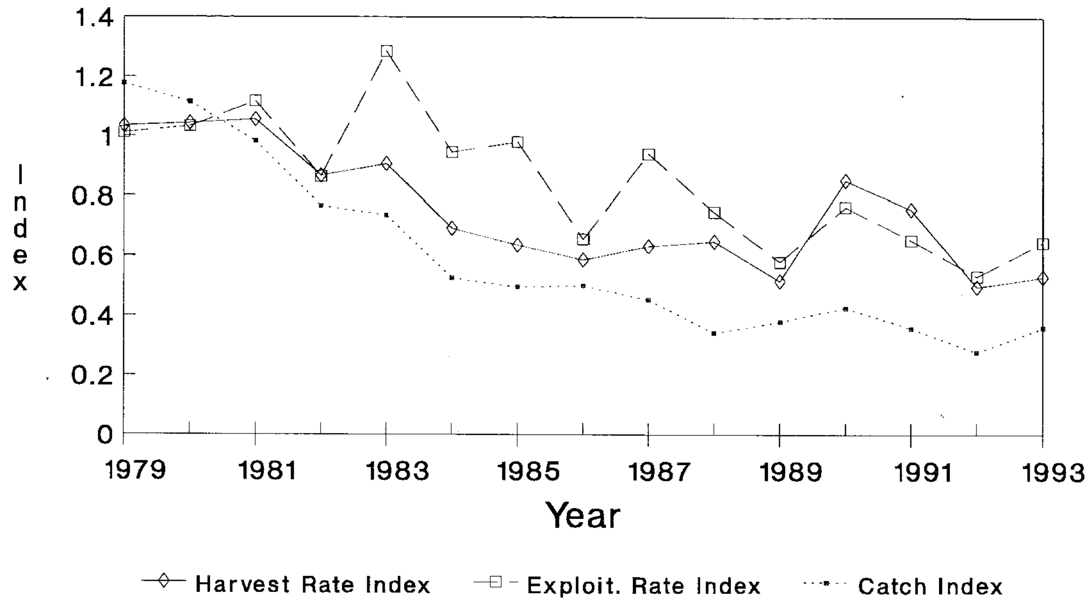
Appendix Table B3. Comparison of the *harvest rate index* with the *exploitation rate index* for West Coast of Vancouver Island Troll fishery.

Catch Year	Abundance Index	Harvest Index	Exploitation Rate Index	Troll Catch	Catch Index
1979	1.04	1.071	1.01	480,373	0.967
1980	1.00	1.189	1.00	488,155	1.022
1981	0.95	0.814	0.83	397,518	0.876
1982	1.02	0.926	1.12	543,783	1.117
1983	0.83	0.908	1.22	385,367	0.972
1984	0.94	1.085	1.45	460,057	1.025
1985	0.94	0.619	0.88	354,068	0.789
1986	0.95	0.706	0.98	342,063	0.754
1987	1.14	0.587	0.66	378,931	0.696
1988	0.94	0.661	0.87	408,724	0.911
1989	0.92	0.376	0.43	203,695	0.464
1990	0.92	0.736	0.78	297,974	0.678
1991	0.74	0.509	0.66	202,919	0.574
1992	0.75	1.013	0.87	346,814	0.969
1993	0.70	0.871	0.93	273,749	0.819

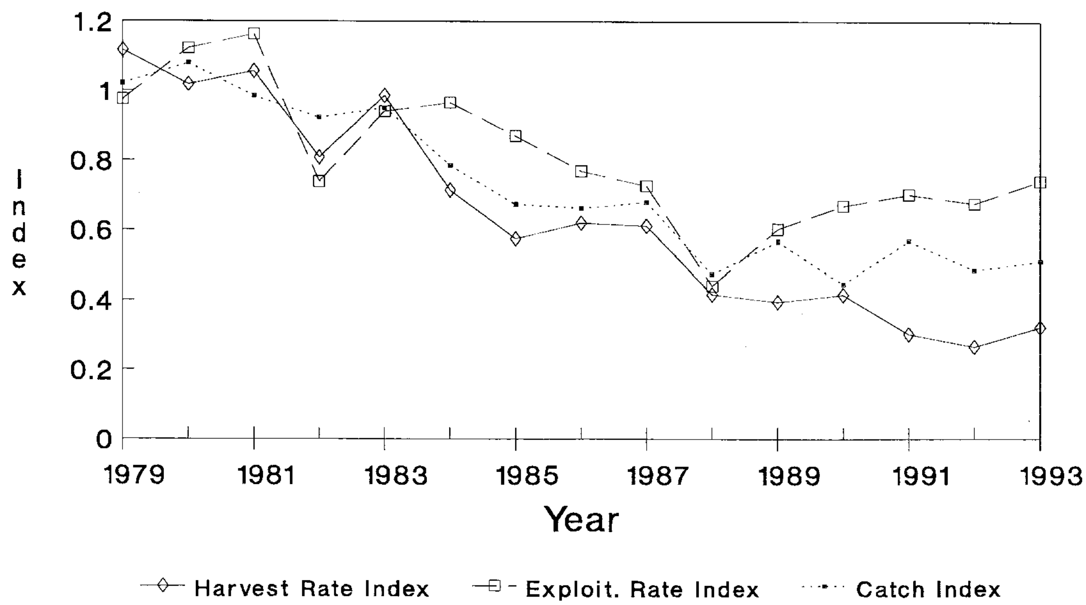
Appendix Table B4. Comparison of the *harvest rate index* with the *exploitation rate index* for Georgia Strait troll and sport fishery.

Catch Year	Abundance Index	Harvest Index	Exploitation Rate Index	Troll Catch	Catch Index
1979	1.17	0.816	0.900	607,278	0.995
1980	1.03	0.978	1.840	644,122	1.199
1981	0.94	1.280	1.359	492,176	1.004
1982	0.86	0.926	0.739	342,291	0.763
1983	0.83	0.706	0.762	303,494	0.701
1984	1.03	1.037	1.111	457,603	0.852
1985	0.97	0.591	0.606	290,524	0.574
1986	0.86	0.863	0.939	225,795	0.503
1987	0.49	0.801	0.699	159,776	0.625
1988	0.43	0.657	0.911	138,728	0.619
1989	0.65	0.491	0.638	161,320	0.476
1990	0.84	0.562	0.480	146,308	0.334
1991	0.53	0.511	0.832	147,749	0.535
1992	0.64	0.572	0.989	153,828	0.461
1993	0.58	0.685	1.187	152,257	0.503

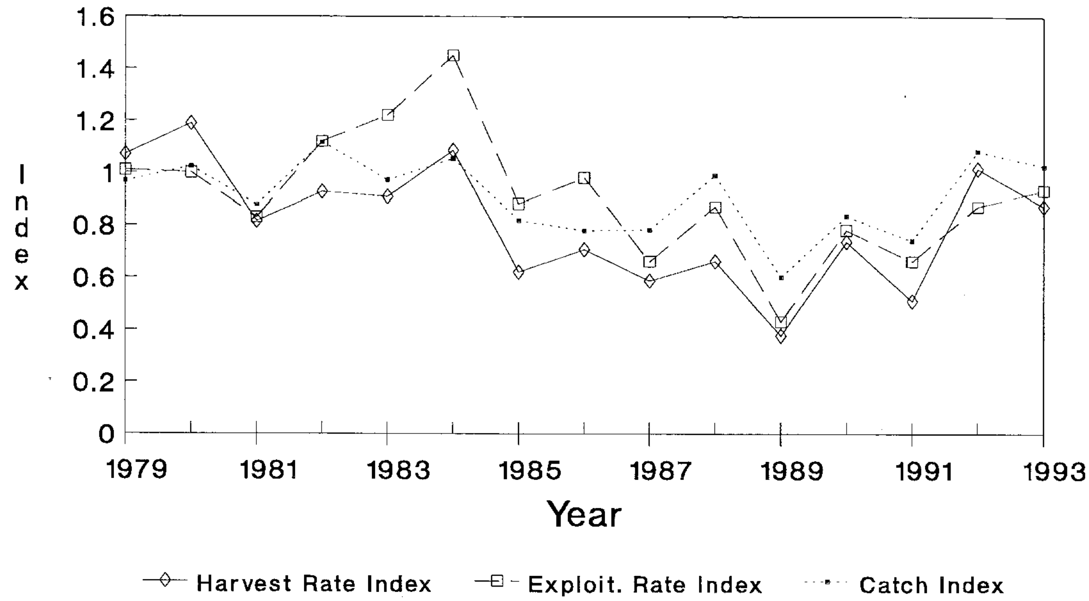
Appendix Figure B3. Comparison of Alaska Troll Fishery Harvest Rate and Exploitation Rate Indices (Landed Catch)



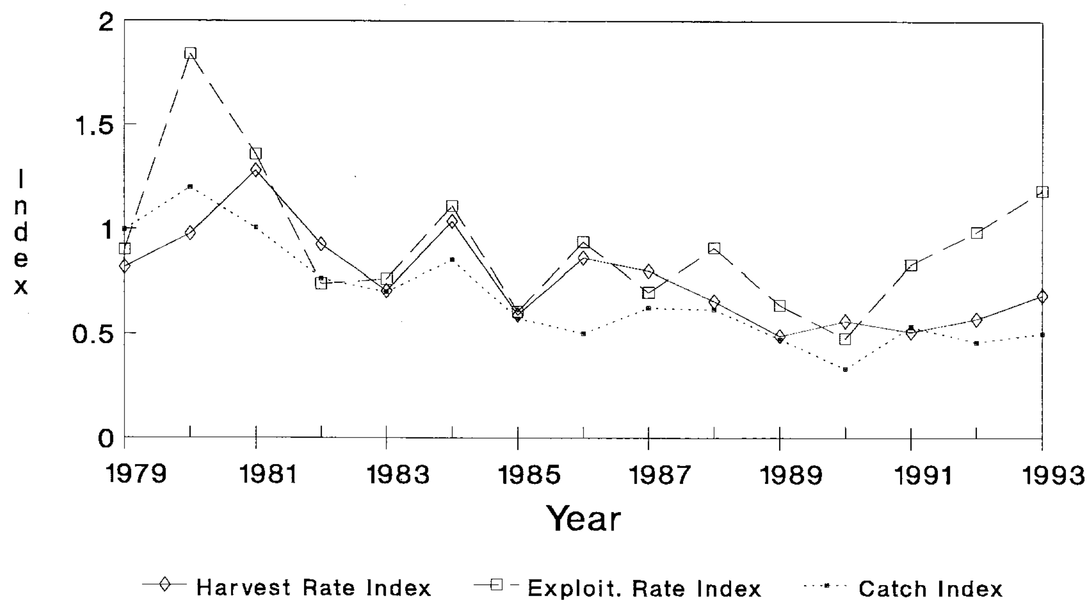
Appendix Figure B4. Comparison of N/C B.C. Troll Fishery Harvest Rate and Exploitation Rate Indices (Landed Catch)



Appendix Figure B5. Comparison of WCVI Troll Fishery Harvest Rate and Exploitation Rate Indices (Landed Catch)



Appendix Figure B6. Comparison of Ga. Strait Fisheries Harvest Rate and Exploitation Rate Indices (Landed Catch)



reported catch compared to a maximum of 13 combinations for the exploitation rate indices), the major stock groups used in the exploitation rate index generally have a much greater weight when calculating the harvest rate index than the new stock and age combinations. Therefore, overall trends in the harvest rate index are very similar to trends in the exploitation rate index.

In general, the *harvest rate index* tended to perform better than the *exploitation rate index* in terms of corresponding better to the combination of catch and abundance data, and in terms of having fewer unexplained peaks or depressions in the index. Calculation of the *harvest rate index* also easily incorporates new stock and age combinations which are not in the base period into the index (so long as there are at least two years of data) and can just as easily be applied to total mortality estimates as to reported catch mortalities.

The harvest rate was related to the catch for a given abundance as follows:

$$Ln(HR_{yr}) = a + b_1 Ln(AI_{yr}) + b_2 Ln(C_{yr})$$

Where

HR_{yr} = The average 1991–1993 harvest rate for reported catch,

AI_{yr} = The abundance index, and

C_{yr} = The troll catch.

The natural log transformations are conceptually reasonable since the true harvest rate can be defined as the observed catch divided by the underlying abundance in the fishery, and both the abundance and harvest rate indices are assumed to be proportionally related to the true abundance and true harvest rate. Although other models and regression techniques may improve on the predictive ability of the current equation, this equation provides good estimates of the estimated harvest rate indices (as evidenced by the high R^2 value of 0.80).

The regression parameters were estimated as:

a = -12.22
b_1 = - 0.302
b_2 = 0.973

Setting the harvest rate equal to the 1991–1993 average of 0.59, solving for the catch which would give this harvest rate at this Abundance Index, the predictive equation for the 1995 troll catch is

$$C_{95} = 166{,}471 \exp(.302\ Ln(AI_{95})/.973).$$

Increasing the troll catch for the sport and net catches yields

$$\text{Total Catch} = 20{,}000 + C_{95}\ /.81$$